ISSN 0198-7356

BARTONIA

JOURNAL OF THE
PHILADELPHIA BOTANICAL CLUB

No. 57, Supplement

Symposium on Rare Plants of Pennsylvania and Adjacent States

Held March 28, 1991. Jointly sponsored by the
Philadelphia Botanical Club and the
Morris Arboretum of the University of Pennsylvania.

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PUBLISHED BY THE CLUB
ACADEMY OF NATURAL SCIENCES, 1900 BENJAMIN FRANKLIN PARKWAY
PHILADELPHIA, PENNSYLVANIA 19103-1195
Issued 21 June 1993

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Bartonia No. 57, Supplement: 1, 1993

Introduction

TED GORDON
President, Philadelphia Botanical Club

This is the first of three symposia presented by the Philadelphia Botanical Club to celebrate its centennial. Indeed, it is fitting that the co-sponsor of a symposium on rare plants of Pennsylvania and adjacent states be our host, the Morris Arboretum of the University of Pennsylvania. In 1979, the Arboretum published the *Atlas of the Flora of Pennsylvania,* and since that time, annual field surveys to update our information on critical species have been conducted under the leadership of Ann Rhoads, Chair of Botany here at the Arboretum. The development of a computerized database and the investigation of the applications for this database, in the use of development planning, for example, are vital components of this undertaking.

Although collecting-trips were initiated by the Morris Arboretum in the mid 1930s, documentation of the local flora by the Philadelphia Botanical Club began even earlier. It was 1891 when the Club organized at the Academy of Natural Sciences "to further the interest of botany and to make a checklist and herbarium of the plants within a radius of 50 miles of Philadelphia," a jurisdiction that, of course, extends beyond the borders of Pennsylvania into New Jersey, Delaware, and Maryland. In the past 100 years, club members have contributed thousands of specimens to the Academy herbarium. The local collection is one of the finest in the world! Thanks to the steadfast encouragement of Alfred E. Schuyler, editor for more than twenty years of *Bartonia,* our Club's journal, interest in monitoring the local flora continues to mount. Judging from the ambitious field trip schedules of the past several years, the Club has not lost any of the enthusiasm exhibited by its founders.

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Bartonia No. 57, Supplement: 2–8, 1993

Rare Plants and Rare Plant Communities of Presque Isle

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The flora and vegetation of Presque Isle Peninsula, the finest example of a recurved, compound sand spit along the southern shore of Lake Erie, were surveyed by the Botany Department of The Cleveland Museum of Natural History from May 1985 through 1990. A floristic survey for all vascular plants was conducted and rare plant communities and specific occurrences of rare vascular plants were mapped for the peninsula and adjacent waters of Lake Erie. Responses of rare natural communities to fluctuating lake levels were documented. Observations were made on apparent threats to rare species including exotic species encroachment, deer overpopulation, and inadvertently poor management practices.

The Museum initiated this study because 79 years had elapsed since the last thorough study of plants on the peninsula. That study, conducted in 1905 and 1906 and published in 1909 by Otto E. Jennings, documented the occurrence of several dozen plants currently listed as Plants of Special Concern in Pennsylvania (POSCIP) by the Pennsylvania Natural Diversity Inventory (PNDI), Department of Environmental Resources. John Miller's Flora of Erie County (1923) provided some important historical rare plant records not included in Jennings (1909).

DESCRIPTION OF AREA

Presque Isle Peninsula extends northeast into Lake Erie from Mill Creek Township, Erie County, Pennsylvania. The City of Erie is located on the mainland south of the peninsula, and the body of water between the city and the peninsula is known as Presque Isle Bay. Most of the peninsula (approximately 6 miles of its length) is located on the Erie North, PA U.S.G.S. 7 1/2 minute quadrangle map. One mile of the peninsula, including the attachment to the mainland is located on the Swanville, PA quadrangle map. All features referred to in this paper can be found on the topographic maps.

Most of the 3,000 acres of the peninsula are included within Presque Isle State Park, established in 1921. PA Bureau of Parks manages the park for both recreation and conservation. At this time most of the park is undeveloped except for 11 bathing beach areas and a perimeter state highway (PA Rt. 832) that provides access to beach areas. There are relatively few buildings within the park but each beach area has restrooms and there are several park buildings.

For thousands of years, waves generated by prevailing westerly winds have eroded lake bluffs to the west of Presque Isle. The sand component from the bluffs moves eastward along the shoreline by littoral drift to the base of the peninsula and along the lake side (northwest shore) of the peninsula. Relatively light, wind-blown silica sand tends to accumulate on the upper beach shelf, and is crucial to maintaining dunes along the lake side of the peninsula.

Shoreline jetties, sheet piling, and offshore breakwaters placed along the lake side of the peninsula during the last century have accumulated sand from the littoral drift system to the windward (westerly) side of structures and contributed to shoreline erosion downshore (east) of the structures. In an attempt to counter severe beach erosion that has taken place along the lake side of the peninsula between the mainland and the signal tower, PA

Bureau of Parks and the Corps of Engineers have carried out a sand replenishment program. The program began in the 1950s but annual nourishment did not commence until 1974 (Gorechi 1985). Unfortunately, much of the replenishment sand is bank gravel instead of angular silica sand that is so important to dune building.

The major ridges within the park trend from northwest to southeast. The development of these ridges has been linked by Jennings (1909) to major northeasterly storm surge events. New ridges and ponds form at the northeast edge of the peninsula and successively older ridges and ponds are located to the southwest.

A great diversity of natural communities has developed on the complex system of sand ridges, ponds, and bay shore waters. The following natural communities were mapped during the six year study: mixed hardwood forests (dominated by *Quercus borealis–Quercus velutina–Prunus serotina–Acer rubrum*), *Populus deltoides,* sand dunes, emergent marshes, shrub swamps, mixed swamp forests, palustrine sand plains, dry sand plains, and oak savannahs.

METHODS

More than 100 full field days were spent searching for POSCIP species historically reported for the peninsula. (Plants recommended for addition to the POSCIP list at the January 1989, 1990, and 1991 meetings of the PA Rare Plant Committee are included as rare species for this paper.) Many Carnegie Museum specimens from the area were examined along with the John Miller Collection at Edinboro University. (The Miller Collection is now at Carnegie Museum.)

All POSCIP species were mapped on the U.S.G.S. quad maps. Prints made from high resolution aerial negatives on loan to the Museum from the U.S. Army Corps of Engineers were used to map rare natural communities. The scale of the aerials is 1 inch:400 feet.

Voucher specimens of all rare species, except *Opuntia humifusa* that was too rare to collect, have been placed in the Cleveland Museum of Natural History Herbarium, and all rare plant occurrences have been reported to PNDI.

RESULTS AND DISCUSSION

Sixty-four species listed as Plants of Special Concern, or suggested as additions to the list at the January 1991 PA Rare Plant Committee Meeting, were documented at Presque Isle from 1985 through 1990. More than 400 occurrences of the 64 species were mapped.

The following 15 species, historically reported from the peninsula, were not found (those marked with an "*" have not been examined by the author): *Arethusa bulbosa, Carex sartwelli**, *Carex tetanica, Eriophorum gracile, Populus balsamifera**, *Potamogeton gramineus, Potamogeton praelongus, Potamogeton robbinsii, Potamogeton strictifolius**, *Salix candida**, *Salix serissima**, *Scirpus torreyi, Scleria verticillata, Sparganium minimum, Triglochum palustre,* and *Utricularia resupinata.*

The 64 rare species are found in the following six rare communities. No rare species were found within full canopy forests but rare dry sand plain species were found establishing within recent sand blowouts on the forested ridges. The number of rare species in each community is shown in parentheses.

Palustrine Sand Plain (27)
Dry Sand Plain and Oak Savannah (8)
Dunes and Dry Beaches (10)
Aquatic Bed (11)
Mixed Emergent Marshes (7)
Shrub Swamp (1)

A seventh rare community, a sphagnum wetland community, described as the "*Sphagnum-Oxycoccus* Formation" by Jennings (1909), was not found during the study. Two of the 15 rare plants known only from historical records, *Arethusa bulbosa* and *Eriophorum gracile,* were probably restricted to this rare habitat.

There is a historical record for an eighth community. A specimen of the rare tree, *Populus balsamifera,* was presumably taken from the swamp forest community at Presque Isle by Jennings in 1906.

Four rare plants were found that had never before been reported for Presque Isle: *Eleocharis caribaea, Eleocharis intermedia, Geranium bicknellii,* and *Myriophyllum verticillatum. Eleocharis caribaea* and *Myriophyllum verticillatum* are additions to the flora of Pennsylvania.

Based upon Wherry et al. (1979), examination of Carnegie specimens, and field work by the author, the following 12 rare taxa have been reported only from Presque Isle within Pennsylvania: *Ammophila breviligulata, Artemisia campestris* ssp. *caudata, Carex, aquatilis, Carex garberi, Carex viridula, Eleocharis caribaea, Eleocharis pauciflora, Prunus pumila,* var. *pumila, Schizachyrium scoparium* var. *littoralis, Sparganium minimum, Triglochin palustris,* and *Utricularia resupinata.*

Successional changes within all rare communities at Presque Isle, except the highest dunes and dry sand plains, are not unidirectional or generally predictable because Lake Erie levels drive those changes. When the lake level rises: (1) Swamp forest and shrub swamps die back and are replaced by emergent marshes. (2) Emergent marshes along interior pond shores and Presque Isle Bay are replaced by the aquatic bed community. (3) Dry sand plains on interdunal flats, trail flats, and mowed flats are replaced by the palustrine sand plain community. When the lake level falls: (1) Swamp forests and shrub swamps establish again within emergent marshes. (2) Palustrine sand plain replaces the aquatic bed along the shores of interior ponds and Presque Isle Bay. (3) Emergent marsh species, especially *Calamagrostis canadensis,* advance into the palustrine sand plain community as the palustrine sand plain moves downslope onto newly exposed beach flats. (4) Dry sand plains replace palustrine sand plain communities on interdunal flats, trail flats, and mowed flats.

PALUSTRINE SAND PLAIN. The palustrine sand plain is an ephemeral community that occupies open, moist, sparsely vegetated, sandy flats. Standing water is often present in the spring and the water table often drops below the surface during the summer. This community contains 25 rare plants, more than any other in the park. The distribution and abundance of the community is tied to the level of Lake Erie. Typical palustrine sand plain species include: *Cyperus flavescens, Cyperus bipartitus, Hypericum majus, Juncus alpinus, Juncus articulatus,* and *Juncus brachycephalus.*

Many of the rarest species of this community are not present in the park every year. During the high water levels of 1985 and 1986, the community flourished upon moist flats within depressions along inland trails and on wet flats between dunes. When the lake level dropped in 1987 and 1988, visits to the interior trail flats and interdunal flats revealed that the palustrine sand plain community had apparently disappeared from those sites and been replaced largely by dry sand plain species.

Seeds of many of the palustrine sand plain species are apparently stored within dry sands along trail flats during periods of low lake levels and in the moist sandy or peaty substrates beneath the water surface of the interior ponds and the Presque Isle Bay shoreline during periods of high water levels.

During 1985 and 1986, when the lake was very high, no palustrine sand plain community was found along the shore of Presque Isle Bay from Big Bend to the mainland. When the level of Lake Erie dropped in 1987 and 1988, thousands of individuals of the rare plants that compose the community appeared on newly exposed low-relief beach shelves along the Presque Isle Bay shore. This phenomenon was also observed along interior pond shores.

Park management has a profound impact on this community. Many of the rarest species within the community tolerate heavy foot traffic and flourish on trails and frequently mowed areas of the park. Through the six year study, *Calamagrostis canadensis* and other species including *Typha* × *glauca, Phragmites australis, Epilobium hirsutum, Lythrum salicaria* and *Phalaris arundinacea* were observed to invade and quickly replace the community except on areas receiving heavy foot traffic or frequent mowing during the growing season. During the high lake levels of 1985 and 1986, large populations of several rare palustrine sand plain species were found to be commonplace on wet flats that were mowed for public use or on heavily used wet flats along trails. Adjacent unmowed and untrampled areas, typically dominated by *Calamagrostis canadensis,* supported no palustrine sand plain species. The following rare species were found only on trail flats: *Carex garberi, Eleocharis caribaea,* and *Eleocharis pauciflora.*

There is great potential for increasing the acreage of this rare community at Presque Isle. Hundreds of acres of *Myrica pensylvanica–Calamagrostis canadensis* flats could be regularly mowed during the growing season. Park maintenance activities have proved the effectiveness of this succession management technique in several areas.

Three POSCIP species published by Jennings in 1909 that would have inhabited this community were discovered to be other species. *Carex schweinitzii* was determined to be *Carex hystericina, Juncus brachycarpus* was determined to be *Juncus torreyi,* and *Eleocharis compressa* var. *atrata* was determined to be *Eleocharis elliptica.* Four historical species, presumably members of this community, were not found (the last year reported is shown in parentheses): *Carex tetanica* (1869), *Scleria verticillata* (1911), *Triglochin palustre* (1905), and *Utricularia resupinata* (1879). The following rare species were found within the community (an "*" denotes that the species was found associated with wet trail flats): *Agalinis paupercula**, *Aster dumosus**, *Carex bebbii**, *Carex garberi**, *Carex viridula**, *Cyperus diandrus**, *Cyperus engelmannii**, *Cyperus odoratus**, *Eleocharis caribaea, Eleocharis elliptica**, *Eleocharis intermedia**, *Eleocharis olivacea**, *Eleocharis pauciflora**, *Equisetum variegation, Hemicarpha micrantha**, *Hypericum majus**, *Juncus alpinus**, *Juncus balticus**, *Juncus biflorus**, *Juncus brachycephalus**, *Juncus torreyi**, *Lathyrus palustris**, *Lobelia kalmii, Parnasia glauca, Potentilla anserina**, *Potentilla paradoxa,* and *Scirpus smithii.*

DRY SAND PLAIN AND OAK SAVANNAH. The dry sand plain is an open, dry grassland usually dominated by *Sorghastrum nutans* and *Schizachyrium scoparium* var. *littoralis.* This community often occurs as a savannah with widely scattered *Quercus velutina, Quercus rubra,* and *Sassafras albidum.* The community also establishes on blowouts within hardwood forests. Other species common in the dry sand plain include: *Panicum virgatum, Carex muhlenbergii, Carex tonsa, Rumex acetosella,* and *Dichanthelium sabulorum.* The alien species, *Lonicera morrowii,* has invaded much of this community within the park.

One species in this community, *Lithospermum caroliniense,* is on the brink of extirpation within Pennsylvania due to severe grazing by deer. Less than 100 plants occur on the dry sand plains on the peninsula. *Arctostaphylos uva-ursi* has apparently been extirpated from both the peninsula and the state. *Shepherdia canadensis* is another shrub that has been extirpated from the peninsula. *Geranium bicknellii* was found only during 1986 at a site disturbed during construction of a restroom. The species is known to seed bank between episodes of fire within this community at the Indiana Dunes National Lakeshore (Wilhelm 1980). Fire suppression at the Indiana Dunes area has been blamed for deterioration of the community (Wilhelm 1980) and fire suppression has likely had the same negative impact at Presque Isle.

Eight rare species are found on the dry sand plain: *Dichanthelium sabulorum, Dichanthelium oligosanthes, Digitaria cognatum, Geranium bicknellii, Lithospermum caroliniense, Lupinus perennis, Opuntia humifusa,* and *Schizachyrium scoparium* var. *littoralis.*

DUNES. Sand Dunes and drift beaches at Presque Isle support ten rare species: *Ammophila breviligulata, Artemisia campestris* ssp. *caudata, Cakile edentula, Chamaesyce polygonifolia, Cyperus schweinitzii, Lathyrus japonicus, Ptelea trifoliata, Schizachyrium scoparium* var. *littoralis, Sporobolus cryptandrus,* and *Triplasis purpurea.*

Ammophila breviligulata and *Populus deltoides* are the most frequent dune builders, but in some areas *Panicum virgatum, Schizachyrium scoparium* var. *littoralis,* and *Elymus canadensis* are also important. Active dunes at Presque Isle are best developed from the Light House eastward to the tip of the peninsula and fine *Ammophila* dunes are located along the shore of Thompson Bay, northeast of Horseshoe Pond.

The dunes at Presque Isle are the highest impact area from the 5 million visitors that annually use the park. *Ammophila breviligulata* stands on some of the dunes between the Lighthouse and the Signal Tower have breaks in the most heavily trampled sections.

Some POSCIP species characteristic of dunes, including *Cyperus schweinitzii* and *Sporobolus cryptandrus,* grow in abundance on trampled grounds at the highest use areas on the dunes and beaches. Only one rare species, *Prunus pumila* var. *pumila,* reported as a member of the dune vegetation by Jennings in 1909, was not found during the present study. Deer browsing may account for the absence of this plant. The beach areas between the Light House and Signal Tower are browsed so heavily that *Salix exigua* and *Salix eriocephala* seldom exceed a foot in height.

The on-going construction of 58 off-shore breakwaters along the lake side of the park from just north of the mainland to east of the Light House may have a severe impact on the dune community at Presque Isle. Twenty of the breakwaters have been installed. According to information presented at a public hearing held by the U.S. Army Corps of Engineers and PA Bureau of Parks on July 22, 1988, the 58 off-shore breakwaters may reduce the littoral drift of sand by as much as 65%. This reduction may have a negative impact on the formation of new dunes.

AQUATIC BED. This plant community is found along the entire Presque Isle Bay shoreline and within open ponds in the interior section of the park. The interior ponds which have well developed aquatic beds are sometimes sparsely covered with *Nuphar advena, Nymphaea odorata, Brasenia schreberi,* and *Potamogeton natans.*

One alien submersed aquatic plant, *Myriophyllum spicatum,* apparently poses a threat to submersed aquatic plants listed as POSCIP species. Based upon examination of herbarium specimens, *Myriophyllum spicatum* was first collected at Presque Isle in 1950. Prior to that time several specimens of the rare *Myriophyllum sibiricum* had been collected from Presque Isle, but it has not been reported since. According to Cooperrider (1982), this replacement has also taken place in Ohio, and Reznicek and Catling (1989) reported *Myriophyllum sibiricum* to be confined to a single small pond at Long Point, across the lake from Presque Isle. Presque Isle Bay and all interior ponds at Presque Isle that have open water channel connections to Lake Erie contain large populations of *Myriophyllum spicatum.* Three rare submersed species, *Myriophyllum verticillatum, Myriophyllum heterophyllum,* and *Najas gracillima* occur within interior ponds that do not have populations of *Myriophyllum spicatum.* Continued isolation of interior ponds may be necessary for long term survival of rare submersed aquatics now inhabiting them.

The only historical record for *Myriophyllum heterophyllum* was collected by John Miller from Big Pond in 1899. Big Pond currently supports large beds of *Myriophyllum spicatum* and no *Myriophyllum heterophyllum,* but *Myriophyllum heterophyllum* is abundant within Ridge Pond and one other pond without a channel connection to Lake Erie. *Myriophyllum verticillatum* is confined to the unnamed pond between the east shore of Horseshoe Pond and Thompson Bay. Jennings (1909) labeled this pond Aa and estimated the age of this pond to be less than 100 years.

Typical members of the aquatic bed community within Presque Isle Bay include: *Vallisneria americana, Elodea canadensis, Ceratophyllum dermersum, Najas flexilis, Najas guadalupensis, Potamogeton pusillus* var. *pusillus,* and *Potamogeton richardsonii.* The single collection of *Potamogeton perfoliatus* from Misery Bay in 1989 may be the only known extant population of this species within Lake Erie. According to Cooperrider (1982), the species was last collected from Ohio in 1896 and Reznicek and Catling (1989) did not find the species at Long Point during their recent survey there.

Eleven submersed POSCIP species were documented within aquatic beds at Presque Isle: *Megalodonta beckii, Najas gracillima, Myriophyllum heterophyllum, Myriophyllum verticillatum, Potamogeton perfoliatus, Potamogeton illinoensis, Potamogeton richardsonii, Potamogeton zosteriformis, Ranunculus longirostris, Utricularia intermedia,* and *Utricularia minor.* Four species, historically reported from the aquatic bed community of Presque Isle, were not located (the most recent collection date for each is shown in parentheses): *Potamogeton gramineus* (1948), *Potamogeton praelongus* (1930), *Potamogeton robbinsii* (1928), and *Potamogeton strictifolius* (1868).

MIXED EMERGENT MARSHES. The emergent wetland marshes at Presque Isle cover hundreds of acres and include: *Typha* swamp, *Carex stricta–Carex aquatilis* tussock meadows, non-persistent *Nuphar–Nymphaea–Pontederia* marshes, and *Acer rubrum–Quercus palustris–Nyssa–Cephalanthus* savannahs with extensive mixed herbaceous marsh openings. *Typha* × *glauca* and *Phragmites australis* have aggressively invaded much of this community type within the park. *Phalaris arundinacea* also poses a threat to the emergent marshes. There are no historical records for *Phalaris,* small populations have become established between Big Bend and the mainland.

Seven rare emergent wetland species were documented within this community type: *Carex aquatilis, Carex pseudocyperus, Cladium mariscoides, Eleocharis quadrangulata, Scirpus acutus, Scirpus fluviatilis,* and *Zizania aquatica.* Three species historically reported from the community were not found (the last date of collection is shown in parentheses): *Carex sartwellii* (186?), *Scirpus torreyi* (1879), and *Sparganium minimum* (1880).

SHRUB SWAMP. Shrub swamps within the peninsula are often dominated by pure stands of *Cephalanthus occidentalis.* Mixed shrub swamps, dominated by mixtures of *Cephalanthus, Vaccinium corymbosum, Viburnum recognitum, Ilex verticillata, Alnus rugosa, Cornus amomum* spp. *obliqua,* and *Rosa palustris* also occur frequently within the peninsula. A single rare shrub, *Salix gracilis,* was found in this community. Two rare shrubs, historically reported from the peninsula were not found (the last date for each is shown in parentheses): *Salix candida* (1916), and *Salix serissima* (1916).

CONCLUSION

Presque Isle contains more Plants of Special Concern in Pennsylvania than any other area of similar size within the state. Long term survival of the present diversity of rare species and rare communities can be accomplished by informed park management.

ACKNOWLEDGEMENTS

The author thanks Frederick Utech, Associate Curator of Carnegie Museum Herbarium for providing assistance in examining Presque Isle specimens and Don Snyder, of Edinboro University for providing access to John Miller's Presque Isle specimens while that collection was housed at Edinboro. Financial support was received from the PA Wild Resources Conservation Fund, PA Coastal Zone Management, Western Pennsylvania Conservancy and Zurn Industries, Inc. Special acknowledgement goes to Museum Associate, Beverly W. Danielson, who gave more than 100 days to the Presque Isle inventory.

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Bartonia No. 57, Supplement: 9–15, 1993

The Collections of Albert Commons on Delmarva, 1861-1901, with Attention to August 4-5, 1874 and September 9-10, 1875

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When Albert Commons died in 1919, his nephews, Frank W. and Howard W. Commons, donated his herbarium to the Academy of Natural Sciences of Philadelphia. Francis Pennell (1943) called these collections the "most ample botanical collections ever assembled from Delaware." Robert Tatnall (1946) stated: "It gives evidence of care and discrimination on the part of the collector in the identification of his specimens, and of his keenness in detecting new or rare material in the field." At his death, Albert Commons was also known as a mycologist, having collected 1300 species of fungi (now at the Carnegie Museum of Natural History, and the Academy) and 160 species of lichens (Harshberger 1899). Many duplicates of Commons' collections were sent out, notably to the Plant Pathology Herbarium of Cornell University, Herbarium Universitatis Florentinae, Gray Herbarium of Harvard University, Missouri Botanical Garden, New York Botanical Garden (639 sheets), and the Smithsonian Institution (Lanjouw and Stafleu 1954). His importance was such that Ashe (1898) named *Panicum commonsianum* after him.

Albert Commons was born the son of John and Ann (Phipps) Commons in the village of Doe Run, Chester Co., PA on January 23, 1829. Albert was sickly and greatly influenced by his older brother Franklin. In 1839, Albert, while a student at the Academy at Unionville, purchased a copy of Darlington's 'Flora Cestrica,' and had a tin collecting box made (Harshberger 1899). At his brother's demise in 1842, they had collected about 500 specimens. Albert's first botanical trip in Delaware appears to have been in 1842, soon after he moved to the Commons farm near Centreville, New Castle Co., DE.

The 4262 specimens of Albert Commons that we have located are of great interest for botanists to understand the historical flora of the Delmarva Peninsula. His collections of *Rhynchospora knieskernii* and *Eupatorium resinosum* in 1874 and 1875 are of concern due to the potential status of these taxa as federal endangered or threatened species. This paper reconstructs Commons' field activities for this period and concludes that both species were collected by Commons in Delaware.

THE CASE OF *RHYNCHOSPORA KNIESKERNII*

Albert Commons never knew that he had collected *Rhynchospora knieskernii.* He died without making such a claim, leaving us his notebook (now at the Claude E. Phillips Herbarium) with this species marked as something to be sought in Delaware. The facts in the case are these: (1) On August 5, 1874 Albert Commons collected a specimen that he labelled "*Rhynchospora* (?) *capillacea.* Torr. swamps near Gumboro, Delaware" (PH540107). (2) On September 10, 1875, he collected a specimen that he labelled "*Rhynchospora axillaris microcephala.* Britt. swamps, (Baltimore Hundred) Sussex County, Delaware" (PH540117). (3) Both of these specimens languished under these names for 67-68 years until Shirley Gale annotated them in 1941 as *R. knieskernii* Carey (see Gale, 1944).

What floras did a collector use in 1874 and 1875? Wood (1861) and Gray (1867) were widely available, but the latter would have been more commonly used. Gray (1867) does not have keys, and illustrations are given only for genera. *Rhynchospora knieskernii* is lumped together with *R. capillacea* under "spikes chestnut-colored or darker . . . , few-several flowered; stamens 3; bristles usually 6." The other name that Commons used, *R. axillaris* var. *microcephala,* was not published by Britton until 1892 and did not appear in Gray's Manual until the seventh edition (Gray 1908). The handwriting for this specimen is on a different slant, indicating that it was added later, probably between 1908 and Common's death in 1919. A key to *Rhynchospora* and an illustration of *R. knieskernii* were also published by Britton and Brown (1913), but Commons apparently did not check his sheets of *R. knieskernii.*

Rawinski and Cassin (1986) stated of *R. knieskernii,* "the 1875 record may have actually been collected from NJ." This speculation later was noted in the *Endangered Species Technical Bulletin,* a publication of the US Department of the Interior, Fish and Wildlife Service: "It is believed to be endemic to the Pinelands area of southern New Jersey . . ." and "Historically, it was found at 38 confirmed sites in New Jersey." (Anonymous 1990, 1991), without mention of Delaware. The official report from Delaware to the federal government (Trew and Clancy 1991) furthermore stated: "There is doubt as to the validity of these records."

How did these two specimens of Albert Commons assume doubtful status? Conversations with some individuals hired by a private conservation group revealed their belief that Delaware lacked any real importance in rare plants and that Commons actually collected many of his rare plants in New Jersey. Tracing this claim further revealed the rumor that Bayard Long (1885-1969) had remarked that Albert Commons did not always label his specimens until later and that he often confused his collections. No one has offered proof, however, that Albert Commons actually did this. Bayard Long was only 16 at the time of Commons' last collection from Delmarva in 1901. We must also remember that *R. knieskernii* is found in early successional wetlands within oak/pitch pine forest stands. Even in New Jersey, only 27 out of 38 sites for this species still exist (Anonymous, 1991).

THE CASE OF *EUPATORIUM RESINOSUM*

On August 5, 1874, Albert Commons collected *Eupatorium resinosum* from "wet places, near Gumboro" (PH542918). On September 10, 1875, Commons collected *E. resinosum* from "low pine barrens (Baltimore Hundred), Sussex Co." (PH542917). Note also that Commons misidentified a collection of *E. hyssopifolium* as *E. resinosum* collected in sandy woods of Rehoboth on August 1, 1895 (PH542901). The 1874 and the 1875 specimens of this composite were collected on the same dates as *Rhynchospora knieskernii.* In his report on *Eupatorium resinosum Torrey ex D.C.* for the US Fish and Wildlife Service, Mowbray (1986) reported this species as once found in Delaware but now extirpated. A similar report was made by Rawinski and Cassin (1986).

In our study of the floristic geography of Delmarva, we have come to realize that rarity is often a natural and successful "strategy" for survival. We have also come to appreciate the Delmarva Peninsula as a significant link in the Long Island-New Jersey-Delmarva-Carolinas-Georgia chain of pinelands, wetlands, and coastal habitats.

We rediscovered *Oxypolis canbyi* in 1980 in South Carolina, and established its taxonomic status as a distinct species (Tucker *et al.* 1983). We later rejoiced at the discovery of *O. canbyi* in Maryland (Boone, Fenwick, and Hirst, 1984). We have explored *R. knieskernii* sites in New Jersey and *E. resinosum* sites in New Jersey, South Carolina, and

Kentucky (Tucker and Dill, 1989b). We have reconstructed, at least in part, Rafinesque's lost *Florula Delawarica* (Tucker and Dill 1989a), and we have no problem accepting his collection of *Drosera filiformis* in Sussex Co., Delaware, especially since Clyde Reed has re-collected this species (personal communication, 1985). *Aeschynomene* species, sedges, and many other rare plants also share this distribution on Delmarva (Broome *et al.* 1979; Carulli, Tucker, and Dill 1988; Naczi *et al.* 1986; Tucker *et al.* 1979).

We therefore have no problem with the collections of Albert Commons. In fact, we noted (Dill and Tucker 1986) that ". . . contrary to the classic philosophical problem of science being able to establish the negative but not the positive, the biogeographer establishes concretely the presence of a taxon through voucher collections but is never able (over large areas) to state that a taxon is not present. 'Extirpated' taxa have an uncanny (and embarassing) way of reappearing."

Retracing the Steps of Albert Commons

In order to assimilate the flora of Delmarva for his book, Tatnall (1946) compiled a card file of all Delmarva herbarium records of the Academy of Natural Sciences, his herbarium, and the herbarium of the Society of Natural History of Delaware (the latter two now at the Claude E. Phillips Herbarium). Manual examination of this card file revealed many other species that had been collected on the same dates as the *Rhynchospora knieskernii* and *Eupatorium resinosum.* Robert Tatnall did not have access to the herbarium of Edward Tatnall, which had been sent out to Colorado College in 1902 (Anonymous, 1902), but these specimens were returned on permanent loan to the Claude E. Phillips Herbarium in 1980. We also acquired the Delmarva specimens of the Langlois Herbarium at Catholic University upon its dissolution in 1986 (Tucker, Poston and Iltis, 1989). In addition, we have examined specimens of Commons at the New York Botanical Garden and the Smithsonian Institution.

The vascular plant collections of Commons, totalling at least 4262 specimens, were collated for computer analysis. These records were then sorted by date, species, and location. In addition, we are fortunate to have Commons' notebook, which is actually an annotated copy of Edward Tatnall's 1860 *Catalogue.*

Our first record of a Commons herbarium specimen from Delmarva is *Tephrosia virginiana,* collected near Centreville. Commons made this collection in 1861 at the age of 32. Many of his collections were near the family farm in Centreville, but many excursions were made as far south as Salisbury, MD. The last recorded collections were made on September 9, 1901, when Commons was 72, from the Stanton-Ogletown area of Delaware. Our computerized records comprise a nearly complete survey of Albert Commons' activities in Delmarva over a 40-year period. This resource makes it possible for us to compare and contrast Commons' botanical travels with his collections of *R. knieskernii* and *E. resinosum.*

On August 3, 1874, Albert Commons collected *Potamogeton nodosus* from the Red Clay Creek at Greenbank (probably while waiting for the train).

On Tuesday, August 4, he collected the following specimens (names have been modernized to Kartesz and Kartesz (1980) but not all sheets have been annotated recently): *Polypodium polypodioides,* near Gumboro, Cypress Swamp; *Chasmanthium laxum* (*Uniola laxa*), Gumboro, sand; *Eleocharis robbinsii,* Laurel, bank of Broad Creek; *Paronychia fastigiata,* Laurel, Peppers Mill; *Centrosema virginianum,* near Laurel; *Clitoria mariana,* near Gumboro; *Phyllanthus caroliniensis,* near Laurel, sandy soil, road to Peppers Mill; *Toxicodendron toxicarium* (*Rhus quercifolia*), Laurel, pine woods south; *Vitis aestivalis,* near Gumboro, Cypress Swamp; *Vitis rotundifolia,* Gumboro; *Oenothera fruticosa,* near Gumboro; *Nyssa sylvatica,* near Gumboro; *Monotropa uniflora,* Gumboro; *Symplocos tinctoria,* near Gumboro; Cypress Swamp; *Polypremum procumbens,* Gumboro; *Verbena officinalis,* Gumboro, sandy soil; *Pycnanthemum setosum,* Laurel, dry pine woods; *Utricularia juncea,* Laurel; *Lobelia nuttallii,* near Gumboro, sand; and *Senecio tomentosus,* Gumboro.

On Wednesday, August 5, 1874, he collected the following specimens: *Potamogeton epihydrus,* Laurel, Broad Creek at wharf; *Najas gracillima,* Laurel, Broad Creek; *Cyperus compressus,* Laurel, sand; *Cyperus dentatus,* sandy swamps, Sussex Co.; *Eleocharis equisetoides,* ponds between Gumboro & Laurel; *Eleocharis melanocarpa,* between Gumboro & Laurel, wet sand; *Rhynchospora gracilenta,* near Laurel; ***Rhynchospora knieskernii,* near Gumboro, swamp;** *Rhynchospora torreyana,* near Laurel; along road to Gumboro; *Scirpus etuberculatus,* ponds, Sussex Co.; *Smilax pseudo-china,* Laurel; *Xerophyllum asphodeloides,* near Laurel, dry pine woods, rare; *Lophiola aurea,* pine barren bogs between Gumboro & Laurel; *Tipularia unifolia* near Laurel; *Myrica cerifera* Laurel; *Myrica pensylvanica* Laurel; *Quercus ilicifolia* near Laurel; *Quercus marilandica* near Laurel; *Paronychia fastigiata* Gumboro, dry woods; *Minuartia caroliniana* (*Arenaria caroliniana*) near Little Hill, dry sand; *Desmodium marilandicum* Laurel; *Rhynchosia tomentosa* Pepperbox, ¾ mi NE, sandy pine barrens, Little Hill Church; *Hypericum denticulatum* var. *denticulatum* (*H. denticulatum* var. *ovalifolium*), near Laurel, pine barrens; *Viola pedata,* Laurel, pine barrens; *Chimaphila maculata,* Laurel; *Vaccinium stamineum,* Gumboro, woods; ***Eupatorium resinosum,* near Gumboro, wet places;** and *Pityopsis graminifolia* (*Chrysopsis graminifolia*), Laurel, pine barrens SE. By August 7, he returned to Centreville, where he collected *Vitis vulpina, Physalis alkekengii,* and *Lobelia cardinalis.*

On September 3, 1875, Albert Commons collected *Impatiens capensis, Solanum nigrum,* and *Scrophularia marilandica* at Mt. Cuba and near Centreville. On the morning of Thursday, September 9, he collected *Leersia virginica* from Centreville, and, on continuing his travels south that day, he collected the following specimens: *Lycopodium appressum,* Cedar Neck, sandy bogs; *Scleria reticularis* (*S. muhlenbergii*), Felton; *Ilex glabra,* Frankford; *Eryngium aquaticum,* Felton, sandy ditches; *Bartonia virginica,* near Frankford, Cypress swamp; and *Pluchea camphorata,* Gumboro, cypress swamp E. He probably arrived in Sussex Co. late in the day on September 9, so his list for that day is quite naturally short.

On Friday, September 10, he collected the following specimens: *Ruppia maritima,* Cedar Neck; *Triglochin striata,* salt marshes below mouth Indian River; *Eragrostis refracta,* Cedar Neck, moist sand; *Aristida lanosa,* Cedar Neck; *Paspalum dissectum,* Cedar Neck, pond 2 ft deep; *Paspalum floridanum* var. *glabratum,* Rehoboth, S; *Panicum amarum,* Cedar Neck; *Dichanthelium aciculare* (*Panicum angustifolium*), Frankford; *Cenchrus tribuloides,* Cedar Neck, seashore; *Schizachyrium scoparium* var. *scoparium* (*Andropogon scoparius*), Cedar Neck; *Schizachyrium scoparium* var. *littorale* (*Andropogon littoralis*), Cedar Neck (N of Ocean View); *Cyperus tenuifolius,* moist soil, Baltimore Hundred; *Eleocharis tortilis* (*E. simplex*), Baltimore Hundred; *Psilocarya scirpoides,* Baltimore Hundred; *Rhynchospora capitellata,* Frankford, moist soil; ***Rhynchospora knieskernii,* Baltimore Hundred;** *Scleria reticularis* (*S. muhlenbergii*), Cedar Neck; *Scleria pauciflora,* Baltimore Hundred; *Eriocaulon decangulare,* Cedar Neck, ocean shore; *Xyris difformis,* Baltimore Hundred; *Juncus acuminatus,* Frankford; *Juncus roemerianus,* salt marsh of Indian River; *Lachnanthes caroliniana* (*L. tinctoria*), Cedar Neck; *Spiranthes tuberosa,* Frankford; *Quercus falcata,* Frankford; *Polygonum glaucum,* sea shore S of Indian River; *Polygonum ramosissimum,* dry sand, S of Indian River, Baltimore Hundred; *Amaranthus pumilus,* Baltimore Hundred, sea beach; *Atriplex arenaria,* sandy seashore, Baltimore Hundred; *Salicornia virginica* (*S. bigelovii*), Cedar Neck, salt marsh; *Salicornia europaea,* Cedar Neck, salt marsh; *Suaeda linearis,* Cedar Neck, salt marsh; *Desmodium laevigatum,* near Frankford, woods; *Kosteletzkya virginica,* Cedar Neck, salt marsh; *Hudsonia tomentosa,* Cedar Neck, S of Indian River; *Viola lanceolata,* Cedar Neck; *Lythrum lineare,* Cedar Neck; *Oenothera humifusa,* dry sand, coast S of Indian River Inlet; *Myriophyllum pinnatum,* Cedar Neck, ponds; *Eryngium aquaticum,* Cedar Neck, wet places; *Centella erecta,* Cedar Neck, S of Indian River; *Chimaphila umbellata,* Frankford; *Polypremum procumbens,* near Frankford; *Sabatia stellaris,* Cedar Neck near Ocean View; *Centaurium pulchellum,* Cedar Neck N of Ocean View; *Gentiana autumnalis* (*G. porphyrio*), Sussex Co. pine barrens; *Asclepias lanceolata,* Cedar Neck N of Ocean View; *Gratiola pilosa,* Frankford, sandy soil; *Agalinis maritima* (*Gerardia maritima*), below Indian River Inlet, salt marsh; *Utricularis inflata,* Cedar Neck, Baltimore Hundred; *Galium pilosum,* Frankford, sandy soil; *Lobelia puberula,* Cedar Neck, N of Ocean View; ***Eupatorium resinosum,*** **Baltimore Hundred, low pine barrens;** *Eupatorium serotinum,* Baltimore Hundred; *Pityopsis graminifolia* (*Chrysopsis graminifolia*), sandy pine barrens, Sussex Co.; *Solidago erecta,* Baltimore Hundred; *Euthamia galetorum* (*Solidago tenuifolia*), Cedar Neck, salt marsh; *Aster concolor* Baltimore Hundred, dry sand; *Aster nemoralis* Frankford, swamp E; *Aster novi-belgii* Frankford; *Aster tenuifolius* Baltimore Hundred; *Pluchea foetida* Cedar Neck, swamps; and *Prenanthes autumnalis* Ocean View, N, Baltimore Hundred. By September 15, he had returned to New Castle Co., where he collected *Heliopsis helianthoides* from Mt. Cuba.

Students of Delmarva plant geography may wish to note that there is a Salisbury in Kent Co., Delaware and a Centerville in Sussex Co., Delaware (Heck *et al.,* 1966). According to Robert Tatnall's card file, there are also two Cedar Necks; one between Cedar Creek and Mispillion R., the other south of Indian River Bay, between White Creek and the ocean. All but one of Commons' 'Cedar Neck' records (18 in number) are under date of 10 Sept 1875 as are also his 'Baltimore Hundred' or 'seashore S. of Indian R.' (10 in number). The one exception is *Spergularia marina* (A.C. 'Cedar Neck' 16 Jy 1896), but *Heliotropium* (Slaughter Beach 16 Jy '96) shows that Commons was in upper Sussex Co. at that time. It seems clear that all Cedar Neck records of 10 Sept '75 refer to the Indian River locality.

We have assembled the location information from these specimens and correlated them with Beers (1868) and Delaware place names (Heck *et al.* 1966). Two putative routes are revealed on today's highway maps. The trip August 4–5, 1874 was apparently east from Laurel on Rt. 24, south on Rd. 422A, east on Rd. 422, east on Rd. 427, south on Rt. 26 to Gumboro, and then east on Rt. 54 to the Cypress Swamp. The trip on September 9–10, 1875 was apparently east from Gumboro on Rt. 54, north through the Cypress Swamp on the "South West Bridge" (no longer extant), north on Rd. 406, south on Rd. 405 to Frankford, south on Rd. 376, north on Rd. 375 to Omar, east on Rd. 54 to Clarksville, east on Rt. 26, north on Rd. 357 through Cedar Neck, east on Rd. 360, and then north on Rt. 1 to Rehoboth.

We can also postulate potential habitats along these routes. Many of the species, particularly *R. knieskernii* and *E. resinosum,* could have been collected from wet meadows on the edges of forests and in forest clearings, such as those which persisted until recently east of Ellendale, DE. Atlantic white cedar swamps in this area are particularly important for rare species on the Delmarva Peninsula (Dill *et al.* 1987). We note that the current site of Ryan's blueberry farm, just north of the Cypress Swamp, is dominated by *Panicum hemitomon,* a species which we have only otherwise found correlated with Delmarva Bay or bay-like habitats.

Much environmental change has occurred in the Cypress Swamp since Commons' trips in 1874 and 1875. The standing cypress trees were extensively harvested for shingles. After the Civil War, the buried logs were mined. Then, in 1930, a devastating fire hit the Cypress Swamp; it burned for eight months. After the fire, attempts were made to drain the swamp and farm it. In 1961, Edmund H. Harvey formed Delaware Wild Lands, Inc. and subsequently purchased 11,000 acres of the Cypress Swamp.

SUMMARY AND CONCLUSIONS

Our research supports the hypothesis that Albert Commons collected *Rhynchospora knieskernii* and *Eupatorium resinosum* in Delaware in 1874 and 1875:

(1) Ninteenth century field botanists travelled by foot, horse and buggy, boat, and/or train, all of which facilitated close botanical observation and collection. The roads of this era were dirt with few highway markers. Consequently, labels of this era were also vague.

(2) Information from specimen labels and notes conclusively place Albert Commons in Delaware on August 5, 1874 and September 10, 1875. At this time we find no evidence that he was in New Jersey on either of these dates. *Polypodium polypodioides, Symplocos tinctoria, Rhynchosia tomentosa, Pityopsis graminifolia, Triglochin striata, Eragrostis refracta, Scirpus etuberculatus,* and *Juncus roemeriianus* were all collected by Commons on August 4-5, 1874 and September 9-10, 1875. These species reach their northern limit in Delaware and have never been collected from New Jersey.

(3) Many of the sites of Albert Commons' botanizing have succumbed to residential, industrial, recreational, and agricultural development, especially in the vicinity of the Great Cypress Swamp in Sussex Co. Habitats, communities, and ecosystems may be extirpated as well as local populations of species. The failure to find *R. knieskernii* and *E. resinosum* today in Delaware does not mean that Albert Commons mislabelled his collections, either intentionally or accidentally.

(4) The 4262 Delmarva specimens which Albert Commons collected from 1861 to 1901 represent a significant portion (estimated 78%) of the 2259 vascular taxa listed by Tatnall (1946). Albert Commons' collections, often of overlooked taxa such as grasses and sedges, represent an historical treasure painstakingly assembled over a lifetime. His work firmly establishes him, along with Edward Tatnall and William M. Canby, as a member of the trinity of founding botanists of the Delmarva Peninsula.

ACKNOWLEDGMENTS

We thank Mr. Robert Naczi and Mrs. Nancy Seyfried for staunchly defending the honor of Albert Commons on numerous occasions. We also thank Mrs. Nancy Seyfried and Mr. Joseph M. McLaughlin for checking and summarizing these records and Ms. Dana Degano for her expertise on FileMaker® Plus. This is contribution No. 14 from the Claude E. Phillips Herbarium.

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Bartonia No. 57, Supplement: 16–41, 1993

Rare Vascular Plants Associated with Limestone in Southwestern Franklin County, Pennsylvania

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We have observed 16 species of "Plants of Special Concern in Pennsylvania" (PNDI 1991) in the limestone lands of southwestern Franklin County, a region which adjoins Maryland along Pennsylvania's southern border. Several of these species have robust populations, and four of them are not known to occur elsewhere in Pennsylvania. Some of the natural communities are of such high floristic quality that they would be noteworthy even if they lacked rare species.

We summarize the 16 rare species and their populations as a group; describe these species and their communities individually; and list additional rare species that have been collected historically in southwestern Franklin County, probably on limestone. We report our field observations for the 16 species and review the literature on their range, habitat, rarity, morphological variation, and breeding system. For the communities, we list the most constant species that we have observed in Franklin County and correlate the most recent community classifications available to us for Pennsylvania and surrounding states. Also, we note the species of Franklin County that are included in two recent reviews on rare vascular plants associated with limestone in Maryland (Boone 1984; Riefner and Hill 1984).

We performed our field work between June 1985 and June 1991 and supplemented our observations with the field reports available from the Pennsylvania Natural Diversity Inventory (PNDI). The voucher specimens cited are deposited in the Shippensburg University Herbarium unless otherwise indicated. Nomenclature follows Kartesz and Kartesz (1980). The range and habitat of each species were summarized from all of the pertinent literature listed in the bibliography, but only representative references are cited in each section. The community classifications cited for Pennsylvania and surrounding states include the systems currently employed by the respective natural heritage programs.

OVERVIEW OF RARE SPECIES AND THEIR POPULATIONS

CHARACTERISTICS OF THE RARE SPECIES. *Taxonomic groups* (*Table 1*). The 16 species are diverse taxonomically: they are distributed among fifteen genera in as many families and orders. The list contains one eusporangiate fern, one leptosporangiate fern, 12 dicotyledons, and two monocotyledons. Five of the six subclasses of dicotyledons (Cronquist 1988) are represented; only the Hamamelidae are lacking. The monocotyledons belong to two of the five recognized subclasses (Cronquist 1988): the Commelinidae and the Liliidae, respectively.

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Habit (Table 1). Only three of the species are woody. The 13 herbaceous species include one annual and 12 perennials, one of which is a vine.

Global rarity (*Table 1*). Eleven of the species are ranked G5, i.e. "demonstrably secure globally," according to the classification employed by The Nature Conservancy. Two have the rank of G4 ("apparently secure globally") while two others have an intermediate designation, G4G5. Only one of them, *Dodecatheon amethystinum,* has the rank of G3. "G3" species have only 21 to 100 occurrences and are either very rare throughout their range, local in a restricted range, or vulnerable to extinction throughout their range (The Nature Conservancy 1982; PNDI 1991).

Rarity in Pennsylvania and surrounding states (*Table 1*). Four of the species are "endangered" in Pennsylvania, i.e. in danger of extinction within the state if they are exploited or their habitats are not maintained. One of them is "threatened," which means that the species could become endangered in the state if exploited or deprived of critical habitat. Five of them are "rare," which means uncommon within the state. At present, six of them are classified as "undetermined" because more data are needed to determine their degree of rarity (Pa. Dept. Environmental Resources 1987; PNDI 1991). Of the seven surrounding states and one Canadian province, Maryland is most similar to Pennsylvania in the rarity of these 16 species: 13 of them are found in Maryland, and ten are of "special concern" (MNHP 1991; Bartgis pers. comm.; also Argus et al. 1982–1987; Delaware Natural Heritage Inventory 1991; Mitchell 1986; New Jersey Natural Heritage Program

TABLE 1. Characteristics of the Rare Species.

Species	Family	Habit[a]	Global rarity[b]	State rarity[c] NY	NJ	DE	PA	MD	VA	WV	OH	ON	North-eastern Limit of Range[d]	Calcareous Affinity[e]
Asplenium resiliens	Aspleniaceae	ph	G5				E	S	+	+	X		F*	o
Bouteloua curtipendula	Poaceae	ph	G5	S	S		R	S	+	S	+	S	ne*	i
Chrysogonum virginianum	Asteraceae	ph	G5	(+)			E	S	+	+	+		F	g
Corallorhiza wisteriana	Orchidaceae	ph	G5		X		U	S	S	S	S		P*	g
Dodecatheon amethystinum	Primulaceae	ph	G3?				T						P	i
Hydrophyllum macrophyllum	Hydrophyllaceae	ph	G5				U	S	+	+	+		F	i
Matelea obliqua	Asclepiadaceae	phv	G4?				U	S	+	+	S		P	o
Ophioglossum engelmannii	Ophioglossaceae	ph	G5				E		+	S	S		F*	o
Opuntia humifusa	Cactaceae	ses	G5	+	+	+	R	+	+	+	S	S	ne	g
Ptelea trifoliata	Rutaceae	ds/t	G5	S	S	(+)	R	S	+	+	+	S	ne*	i
Ranunculus micranthus	Ranunculaceae	ph	G5?	S			R	S	+	+	+		ne	i
Rhamnus lanceolata	Rhamnaceae	ds	G4G5				U		S	S	+		P	o
Ruellia humilis	Acanthaceae	ph	G5				E	S	+	+	+		F	i
Ruellia strepens	Acanthaceae	ph	G4G5		X		U	S	+	+	+		P	i
Salvia reflexa	Lamiaceae	ah	G5				U	(+)		(+)	+	(+)	P*	g
Sedum telephioides	Crassulaceae	ph	G4	(+)	X		R	+	+	+		(+)	P	g

[a] ah: annual herb, ph: perennial herb (non-vine), phv: perennial herbaceous vine, ds: deciduous shrub, ds/t: deciduous shrub or small tree, ses: succulent evergreen shrub. [b] see text for definitions. [c] in PA: E: endangered, T: threatened, R: rare, U: undetermined; in surrounding states and the province of Ontario: S: "special concern" (i.e. rare, threatened, or endangered—including "Watch List" in MD), X: extirpated, +: native and not rare, (+): native to eastern North America, but introduced locally. [d] F: southwestern Franklin Co., P: PA beyond Franklin Co., ne: southern New England or southern Canada, *: extending south and west beyond eastern North America. [e] o: obligate calciphile, g: edaphic generalist, i: intermediate.

1990; Ohio Division of Natural Areas and Preserves 1990; Virginia Natural Heritage Program 1990; West Virginia Natural Heritage Program 1990; Zika 1990; plus sources cited in the next section on community types).

Northeastern limit of range (*Table 1*). According to the literature reviewed below in the section on community types, most of the 16 species are native to the states neighboring Pennsylvania to the south and west (Maryland, Virginia, West Virginia, and Ohio). Only a few of them (i.e. one to four) are native and currently extant in the states to the north and east (New York, New Jersey, Delaware) and in Ontario. Five of the species reach their northeastern limit in southwestern Franklin County, and three are restricted to that region within Pennsylvania (Wherry et al. 1979): *Ophioglossum engelmannii, Asplenium resiliens, Ruellia humilis, Hydrophyllum macrophyllum,* and *Chrysogonum virginianum.* Seven other species reach their northern or northeastern limit in Pennsylvania beyond southwestern Franklin County (Wherry et al. 1979): *Dodecatheon amethystinum, Sedum telephioides, Rhamnus lanceolata, Matelea obliqua, Salvia reflexa, Ruellia strepens,* and *Corallorhiza wisteriana.* The remaining four species range north of Pennsylvania into southern New England, New York, and/or southern Canada.

None of the 16 species have distributions centered on the Coastal Plain, and none are restricted to the Appalachians. All range widely to the south and west in eastern North America; and six extend beyond this region into western North America and Mexico: *Ophioglossum engelmannii, Asplenium resiliens, Ptelea trifoliata, Salvia reflexa, Bouteloua curtipendula,* and *Corallorhiza wisteriana.* At least two species also extend to Argentina: *Asplenium resiliens* (Mickel and Beitel 1988) and *Bouteloua curtipendula* (Hitchcock 1971).

Wherry et al. (1979) recognized four groups of taxa that "reach a geographic limit in Pennsylvania or extend only sparingly beyond its borders." Five of the 16 species are among Wherry's "Midland taxa," which are "widespread in the Mississippi and tributary valleys, ranging eastward in habitats where the soil-reaction tends to be circum-neutral owing to a base-rich underlying rock . . .": *Asplenium resiliens, Dodecatheon amethystinum, Rhamnus lanceolata, Matelea obliqua,* and *Bouteloua curtipendula.* The "Appalachian taxa," which are "widespread in the southern Appalachians from northern Alabama . . . [to] Maryland," include "*O. calcicola*" (*Opuntia humifusa* in part), *Sedum telephioides,* and *Chrysogonum virginianum.* Only "*O. compressa*" (*Opuntia humifusa* in part) and *Corallorhiza wisteriana* are among the "Lowland taxa," which are "widespread . . . on the Atlantic–Gulf Coastal Plain . . . [and] in the Great Lakes lowland." None of the 16 species are "Northern taxa."

Keener and Park (1986) elucidated the distributional patterns of plant species within Pennsylvania. They listed *Asplenium resiliens, Sedum telephioides, Ruellia humilis,* and *Chrysogonum virginianum* among the species that are restricted to the southern part of the Valley and Ridge Province in Pennsylvania and reach their northern limits there. These authors included *Ranunculus micranthus* among the species that range across the southern part of the state.

Calcareous affinity (*Table 1*). Species of plants that occur over limestone differ in their degree of fidelity to it. The literature reviewed below implies that the 16 species compose a spectrum in this feature. At one extreme are the obligate calciphiles such as *Ophioglossum engelmannii, Asplenium resiliens, Rhamnus lanceolata,* and *Matelea obliqua.* They may be edaphically specialized, for they occur exclusively on substrates that are high in calcium, namely calcitic or dolomitic limestone, or soils derived from these parent materials (Riefner and Hill 1984). At the opposite extreme are edaphic generalists, which occur on a broad variety of substrates, calcareous and non-calcareous, throughout their ranges.

Opuntia humifusa and *Sedum telephioides* are obvious examples; but *Salvia reflexa, Chrysogonum virginianum,* and *Corallorhiza wisteriana* are also in or near this group. The seven remaining species are intermediate, occurring on limestone but also other substrates, especially those of basic or circumneutral pH such as diabase, serpentine, calcareous shale or sandstone, and alluvial soils derived from non-acidic parent materials (Riefner and Hill 1984). Listed in an approximate, descending order of fidelity to limestone, the "intermediate" species are: *Dodecatheon amethystinum, Ruellia humilis, R. strepens, Ptelea trifoliata, Hydrophyllum macrophyllum, Ranunculus micranthus,* and *Bouteloua curtipendula.*

CHARACTERISTICS OF THE POPULATIONS (TABLE 2). The entries after each species in Table 2 represent the known populations on limestone in southwestern Franklin County. Ten of the species have only one or two populations, five species have three or four populations, and one species has eight populations.

Physiographic sections (*Table 2*). In southwestern Franklin County, as in Pennsylvania as a whole, limestone bedrock underlies extensive portions of the Great Valley Section and the Appalachian Mountain Section, which are the two subdivisions of the Valley and Ridge Province (Anon. 1990; Berg et al. 1989; Long 1975; O'Neill 1964). The 16 species are about equally divided between the two physiographic sections. Six of them are only known from the Great Valley Section, five others have been found only in the Appalachian Mountain Section, and the remaining five occur in both regions.

Of the 40 populations of the rare species, 19 are in the Great Valley Section and 21 are in the Appalachian Mountain Section. Most of the Great Valley populations are in two clusters. Eight populations occur just west of the Conococheague Creek while seven others are centered around its main tributary, the West Branch. The Appalachian Mountain populations are concentrated around Licking Creek and one of its tributaries, Little Cove Creek. Three of the populations along Licking Creek are actually in Maryland, within a few meters of Pennsylvania. Both Licking Creek and the Conococheague Creek are tributaries of the Potomac River.

Geologic formations (*Table 2*). The rare species occur on nine geologic formations representing three successive geologic periods of the Paleozoic era (Berg et al. 1980; Berg and Dodge 1981; Clark 1970; Geyer and Wilshusen 1982; Vokes 1957). The standardized abbreviations of the formations are given in parentheses:

Devonian: Onondaga and Old Port Formations, undivided (Doo);
Devonian and Silurian: Keyser and Tonoloway Formations, undivided (Dskt);
Silurian: Bloomsburg and Mifflintown Formations, undivided (Sbm); Clinton Group (Sc); Wills Creek Formation (Swc);
Ordovician: Chambersburg Formation (Oc), Rockdale Run Formation (Orr), St. Paul Group (Osp), Stonehenge Formation (Os).

All of the species with more than one population occur on more than one of the above formations. Richest in rare plants are the Onondaga and Old Port Formations, undivided, with eight populations representing eight species; and the St. Paul Group (plus the adjoining Chambersburg Formation), with 14 populations among eight species. The remaining six formations each support only one to six populations.

In some locations, the limestone bedrock of southwestern Franklin County exhibits characteristics of karst topography, including outcrops, caves, and sinkholes (Davies and Legrand 1972). Southwestern Franklin County also contains shale and sandstone (Berg and Dodge 1981; Long 1975). On Ordovician shale of this region, the junior author has discovered four state-rare species: a single plant of *Trifolium virginicum* (Walck 474,

TABLE 2. Characteristics of the Populations.

Species	Physiographic Section[a]	Geol. Form.[b]	Elev. (m)	Soil Map Unit[c]	Slope			Comm. type[f]	Shading[g]	Moisture[h]	Population	
					Position[d]	Aspect	Degree[e]				Area[i]	Size[j]
Asplenium resiliens	GV	Orr	146	HkD	l	N	s	C	s	m	B	b
	AM	Doo	152	HkD?-Md.	l	NNW	s - v	C	s	m	B	b
	AM	DSkt	146	HkD	u	NE	s	C	f	m	B	b
	AM	Swc	140	Ph: HkD?	l	NNE	s	C	s	m	B	a
Bouteloua curtipendula	GV	Oc/Osp	171	HkD	m	E	g	W	o	x	C	d
Chrysogonum virginianum	GV	Os	152	HkD	u	NW	g	U	s - f	m	D	c
	AM	DSkt	143	HhD3	u	SW	m	U	f	m	A	a
Corallorhiza wisteriana	AM	Doo	150	HkD	l	SE	m	U	s - f	m	C	b
Dodecatheon amethystinum	GV	Os	152	HkD	u	NW	g - m	R	f - o	m	D	d
	AM	Doo	247	HeB	u - c	NW	g - m	U	f	m	C	e
	AM	DSkt	152	HhD3	m	W	m	U	s - f	m	B	c
	AM	Swc	143	HhD3	u - c	NW - SW	g	U	s - f	m	C	c
Hydrophyllum macrophyllum	AM	Doo	150	HkD	l	SE	m	U	s- f	m	D	d
	AM	Dskt	143	RyC	l	W	s	U	s	m	B	a
Matelea obliqua	GV	Oc/Osp	174	HkD	m	E	g	W	f	m/x	B	a
	AM	Doo	140	HkD	l	SE	m	U	s - f	m	B	a
	AM	Swc	143	HhD3	l	S	m	U	f	m	B	a
Ophioglossum engelmannii	GV	Osp	165	HkD	m - u	NE	g	W	o	m/x	B	c
Opuntia humifusa	GV	Oc/Osp	158	HkB	l - c	E	g - v	R, C	f - o	x	C	a
Ptelea trifoliata	AM	Sbm	137	Ph	b	—	—	F	f	m	C	a
	AM	DSkt	137	Du - Md.	b	—	—	F	s	m	A	a
Ranunculus micranthus	AM	Doo	150	HkD	l	SE	m	U	s - f	m	C	b
	AM	Sc	168	DIF/Vd	m	S	m	U	f	m	C	c
	AM	Swc	146	HhD3	l - m	S	m	U	f	m	C	c
Rhamnus lanceolata	GV	Oc/Osp	168	HkB	m	E	g	W	f - o	m/x	C	b
	GV	Osp	168	HgB3	f	—	—	U	s - f	m/x	B	a
	GV	Oc/Osp	174	HkD	m	E	g	W	f	m/x	A	a
Ruellia humilis	GV	Oc/Osp	168	HkB	m	E	g	W	f - o	m/x	C	d
	GV	Oc/Osp	174	HkD	m	var.	g	W	o	x	D	d
Ruellia strepens	GV	Orr	146	HkD	l - m	NE	m	U	s - f	m	B	a
	GV	Os	146	HkB	l	SW	g	F	f - o	m	A	b
	GV	Osp	149	Ph	b	—	—	F	f	m	B	a
	GV	Osp	152	HkB	m	E	m	U	s - f	m	B	a
	GV	Osp	168	HgB3	f	—	—	U	f - o	m/x	C	b
	GV	Oc/Osp	177	HkD	c	—	—	U	s	m	B	a
	AM	Doo	137	Ph, HkD	b - l	SE	g - m	F, U	s - f	m	B	b
	AM	Dskt	137	HkD	l	S	g	S	o	m	B	b
Salvia reflexa	GV	Oc/Osp	162	HkB	m	ENE	g	W	f	m/x	B	b
Sedum telephioides	AM	Doo	168	HkD?-Md.	l - u	N	s - v	C	f - o	m	B	c
	AM	Swc	143	Ph: HkD?	l - u	N - NW	s	C	f - o	m/x	B	b

[a] GV: Great Valley, AM: Appalachian Mountain. [b] Slash (/): location uncertain relative to geologic boundary. [c] DIF: Dekalb and Lehew extremely stony soils, 25–75% slopes; Du: Dunning silty clay loam (in MD—extrapolated from Long 1975); HeB: Hagerstown silt loam, 3–8% slopes; HgB3: Hagerstown rocky silty clay loam, 3–8% slopes, eroded; HhD3: Hagerstown silty clay, 5–25% slopes, eroded; HkB: Hagerstown-Rock outcrop complex, 0–8% slopes; HkD: Hagerstown-Rock outcrop complex, 8–30% slopes (HkD?-Md: in MD—calcareous rock outcrop); Ph: Philo silt loam (Ph: HkD?—rock outcrop in Ph map unit); RyC: Ryder silt loam, 8–15% slopes; Vd: Very stony land, Dekalb soil material. [d] c: crest, u: upper slope, m: mid slope, l: lower slope, b: bottom, f: level upland; [e] g: gradual (0–10 degrees), m: moderate (10–45), s: steep (45–90), v: vertical, —: level. [f] Calcareous community types—U: upland forest, R: rocky summit, C: cliff, F: floodplain forest, W: red cedar woodland, S: successional field. [g] s: shade, f: filtered, o: open. [h] m: mesic, x: xeric, m/x: intermediate. [i] A: ≤ 1 m^2, B: > 1 m^2 – 100 m^2, C: > 100 m^2 – 1 ha, D: > 1 ha; [j] a: 1–10, b: 11–100, c: 101–1000, d: 1001–10,000, e: > 10,000.

MOAR), plus populations of *Senecio antennariifolius* (Walck 1987), *Ranunculus micranthus, Opuntia humifusa,* and *Ruellia strepens.* The first two are considered to be endemics of the mid-Appalachian shale barrens (Keener 1983).

Elevation (*Table 2*). The elevation in Franklin County ranges from 130 to 750 meters (U.S. Geological Survey 1979). The 16 rare species occur below 250 meters. Table 2 gives the estimated midpoint of the elevational ranges of the respective populations.

Soil mapping units (*Table 2*). The soils supporting the rare species lie chiefly within five mapping units of the Hagerstown Series, which includes well-drained, upland soils "formed in material weathered from relatively pure limestone" (Long 1975). Fifteen of the 16 species occur wholly or partly within Hagerstown soil mapping units. Thirty of the 40 populations are wholly within Hagerstown mapping units, as are two populations on calcareous cliffs in Maryland. One other population occurs partly on Hagerstown soils and partly on Philo silt loam, a floodplain soil formed in alluvium "from uplands underlain by sandstone and shale" (Long 1975); and two populations are wholly on Philo silt loam. (Two other populations mapped as "Philo" are actually on cliffs that would correspond to "Hagerstown-Rock outcrop complex.") The three remaining populations are within additional mapping units: Dunning silty clay loam, a floodplain soil formed in alluvium "from uplands underlain by calcareous material"; Ryder silt loam, which is formed from thin bedded limestone; and the Dekalb Series, which is derived from "acid sandstone and some shale" (Long 1975). The bedrock of this last population is the Clinton Group (Berg and Dodge 1981), which includes some limestone (Geyer and Wilshusen 1982).

Slope (*Table 2*). All of the species occur wholly or largely on slopes except *Ptelea trifoliata,* which was seen only on bottomlands. Thirty-four of the 40 populations occur on slopes, most commonly mid or lower slope. Only six of them occur entirely on crests, bottomlands, or nearly level uplands. The aspect of the slope differs among the populations. The most frequent aspects are east and southeast, with seven and five populations, respectively. The remaining aspects are represented by one to four populations each.

Community types (*Table 2*). The limestone regions of southwestern Franklin County support a spectrum of community types, which differ in topographic location, vegetational physiognomy, and taxonomic composition. The communities are not always distinct and extensive: they intergrade or interdigitate finely at some sites. This study deals with five community types on limestone (adapted from PNDI 1983): upland calcareous forest, calcareous cliff community, calcareous rocky summit community, floodplain forest, and successional red cedar woodland.[1] In Maryland, four "habitat types" on limestone have been recognized that retain the original character of the vegetation: (1) cliffs and ledges that are partly shaded to fully exposed; (2) well-shaded outcrops along streams and rivers; (3) wooded slopes, often on talus, with accumulation of humus; and (4) calcareous alluvial soils (Riefner and Hill 1984). These habitat types also occur in southwestern Franklin County and partly correspond to the categories employed in the present study. In Franklin County, as in Maryland, most of the upland terrain on limestone has been cleared for agriculture, quarrying, residences, and highways. Nevertheless, some interesting examples of level, upland forests and successional communities are still extant on this type of land.

The populations and species of rare plants are not distributed equally among the five community types. Eighteen of the 40 populations are entirely in upland forest, and eight of the 16 species occur partly or wholly in this habitat type. Next richest is successional red cedar woodland, with eight populations in five species. The remaining community types are each represented by one to six populations and only one or two species.

Shading (*Table 2*). Degree of shading depends on the aspect and degree of slope as well as the physiognomy of the vegetation. The three categories (open, filtered, and shaded) represent qualitative visual estimates when the vegetation is in leaf. In only eight of the 16 species are all of the populations in shaded to filtered lighting. In the other eight species, at least some of the populations are more brightly illuminated. Twenty-eight of the 40 populations occur in shaded to filtered lighting. The other populations occur in open or nearly open lighting.

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[1] In addition, one population of *Ruellia strepens* occurs in a small, mesic "successional field" community (PNDI 1983) along a roadside. The flora is a mixture of native and naturalized grasses, forbs, and shrubs. It resembles the forest edges that *R. strepens* commonly inhabits in the other communities listed.

Moisture (*Table 2*). The general moisture regime of the populations was inferred from the combined factors of position, aspect, and shading. More of the populations occurred in mesic than in xeric sites: 28 of the 40 populations (and seven of the 16 species) occurred solely in mesic habitats (mesic upland forest, floodplain forest, shaded cliff). The remaining 12 populations occurred in xeric or intermediate habitats (xeric upland forest, exposed cliff, calcareous rocky summit, red cedar woodland).

Population area and size (*Table 2*). The populations differ greatly in area and in number of aerial shoots. Areas range from less than one square meter to four hectares. The numbers range from a solitary shoot to more than ten thousand. Whether the shoots represent ramets or genets was not determined, but inferences are made for some of the species listed below. A majority of the populations are small, occupying areas of up to 100 square meters and comprising less than 100 shoots.

Calcareous Community Types and Their Rare Species

XERIC TO MESIC UPLAND FOREST. These communities commonly have a diverse and luxuriant canopy and understory. Many of the species are local: they were observed in only one example of this community type. Such floristic variation among the communities may be related partly to edaphic or topographic differences. However, these communities also exhibit a strong floristic similarity. The following species of canopy trees occur at six or more of the nine examples that were tabulated: *Juniperus virginiana, Celtis occidentalis, Ulmus americana, Carya cordiformis, C. ovata, Juglans nigra, Quercus muhlenbergii, Q. rubra, Ostrya virginiana, Tilia americana, Prunus avium, Cercis canadensis, Acer saccharum s.l., Fraxinus americana and/or F. pennsylvanica.* By the same criterion, the characteristic shrubs and vines are: *Lindera benzoin, Menispermum canadense, Rosa multiflora, Toxicodendron radicans, Lonicera japonica, Viburnum prunifolium, Rubus occidentalis, Parthenocissus quinquefolia,* and *Smilax hispida.* Ericaceae are absent or scarce on the calcareous substrates but are frequent on the adjoining formations of shale or sandstone.

In some of these communities, the native herbaceous flora appears threatened by the vigorous growth of several naturalized Eurasian species, especially *Rosa multiflora, Lonicera japonica, Alliaria petiolata,* and *Hesperis matronalis.* These alien species also abound in floodplain forests described below. In addition to being pressured by competition, many of the native herbaceous species are easily damaged by trampling, some of them are vulnerable to browsing by deer or other herbivores, and a few are so scarce that they could be extirpated by collecting. In some of these communities, for example the stand described by Klotz and Walck (1990), many of the rare or unusual native species occur close to the road. Since the application of herbicides for roadside maintenance could damage or eliminate these populations, infrequent mowing is preferable in such areas.

Similar communities or forest types, not necessarily on limestone, have been described in New York (Reschke 1990): "Appalachian oak-hickory forest" and "rich mesophytic forest"; New Jersey (Breden 1989): "dry-mesic calcareous forest" and "dry-mesic inland mixed oak forest—mixed oak-hardwood subtype"; Pennsylvania (PNDI 1983): "dry-mesic calcareous central forest" and "mesic central forest"; Maryland (Brush et al. 1980): "sugar maple–basswood association"; Virginia (Harvill et al. 1977): "beech–maple–tuliptree forest"; (Rawinski 1990): "submesotrophic to eutrophic forest"; and West Virginia (Core

TABLE 3. Floristic Spectrum (%) of a Mesic Calcareous Forest Community in Southcentral Pennsylvania.

	Taxonomic Group[a]				Habit[b]			Geographic Origin[c]	
	P	G	D	M	W	P	A	Ne	Nd
Southcentral PA[d]	4	1	80	15	23	63	14	81	19
Northeastern US[e]	2	1	70	27	16.5	68	15.5	80	20

[a]P: Pteridophytes, G: Gymnosperms, D: Dicotyledons, M: Monocotyledons. [b]W: woody, P: perennial or biennial, A: annual. [c]Ne: native, Nd: naturalized. [d]Source: Klotz and Walck 1990. [e]Sources: Gleason 1952, Gleason and Cronquist 1964, Fernald 1950.

1966): "mixed hardwood forest: mesic." All of the above (except Rawinski 1990) list *Fagus grandifolia* as an indicator, but we did not see it in our study areas.

The sites each contain one to five of the eight rare species that we have observed in this community type: *Ranunculus micranthus, Dodecatheon amethystinum, Rhamnus lanceolata, Matelea obliqua, Hydrophyllum macrophyllum, Ruellia strepens, Chrysogonum virginianum,* and *Corallorhiza wisteriana.* Thirty of the species that we have observed in this community type are generally restricted to limestone or other basic to circumneutral soils in Maryland: *Aristolochia serpentaria, Anemone canadensis* (extirpated in Maryland), *Delphinium tricorne, Jeffersonia diphylla, Quercus muhlenbergii, Ostrya virginiana, Tilia americana, Hybanthus concolor, Arabis laevigata, A. patens* (perhaps better included in the calcareous cliff or rocky summit community types), *Desmodium glutinosum, Zanthoxylum americanum, Floerkea proserpinacoides, Chaerophyllum procumbens, Matelea obliqua, Hydrophyllum macrophyllum, Phacelia purshii, Lithospermum canescens, Mertensia virginica, Ruellia strepens, Campanula americana, Triosteum perfoliatum, Aster shortii, Chrysogonum virginianum, Carex hitchcockiana, C. jamesii, C. oligocarpa, C. platyphylla, Oryzopsis racemosa,* and *Trillium sessile* (Boone 1984; Riefner and Hill 1984).

Floristic relationships of a mesic calcareous forest. The flora of one of the mesic calcareous forest communities has been studied in detail (Klotz and Walck 1990). The floristic list consisted of the species occurring within the extent of the population of *Hydrophyllum macrophyllum.* A total of 253 species in 69 families was found within an area of about four hectares. The factors contributing to the richness of this flora possibly include calcareous substrate, topographic heterogeneity, edge effect, periodic mowing along the roadside, past removal of trees and bedrock, and invasion by introduced species. Because the flora of this community was surveyed thoroughly, features of its floristic spectrum can be calculated (Table 3). These data are a potential baseline for future floristic studies in this region. This community is proportionally richer than the northeastern United States as a whole in the percentages of dicotyledons and woody species, poorer in the percentage of monocotyledons, and similar in the percentages of annuals and naturalized species. The 12 largest families in the northeastern United States (Fernald 1950) include the 11 largest families in this community.[2] *Carex* is the largest genus in both floras.

This mesic calcareous forest community is floristically related to the Potomac and Ohio drainages of Maryland, West Virginia, southwestern Pennsylvania, and southeastern Ohio

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[2] The families with seven or more species at this site are: Asteraceae (36 species); Poaceae (16); Rosaceae and Ranunculaceae (11); Fabaceae, Brassicaceae, and Apiaceae (10); Cyperaceae (9: all *Carex* spp.); Liliaceae and Caryophyllaceae (7). The Scrophulariaceae would be the other large family in the northeastern United States.

(Klotz and Walck 1990). The affinity with the Ohio drainage can be discerned from the analysis of the geographic relations of the flora of Pennsylvania by Wherry et al. (1979). These authors listed 22 of the species that occur in this community. Eighteen of them are "Midland taxa." In contrast, only one is an "Appalachian taxon," three are "Lowland taxa," and none are "Northern taxa."[3] (The explanation of these categories is given above in the section on Overview of the Rare Species and Their Populations, after the heading: Northeastern limit of range.)

The geographic analysis of the flora of Pennsylvania by Keener and Park (1986) elucidates the southern affinity of this community. Their lists include 76 of its species. Within Pennsylvania, three of them are otherwise confined to the Pittsburgh Plateaus Section (*Delphinium tricorne, Aster shortii,* and *Trillium sessile*); and one of them (*Phacelia purshii*) is confined to "southwestern/southeastern" regions of the state. Fifteen of the 76 listed species range across southern Pennsylvania, 21 are generally south of the glacial boundaries and the Allegheny High Plateaus Section, and six are confined to the provinces southeast of the Allegheny Front (i.e. Valley and Ridge, Piedmont, Coastal Plain). In contrast, only one of the species (*Magnolia acuminata*) ranges across the western part of the state, and none of them have a northern or eastern distribution within Pennsylvania. The remaining 29 species are among the "common native species," which are frequent throughout Pennsylvania.

Rare species of xeric to mesic calcareous upland forest. a. *Ranunculus micranthus* (Gray) Nutt. ex Torr. & Gray, small-flowered crowfoot, ranges from Massachusetts to North Carolina and Oklahoma and also occurs in the Black Hills of South Dakota (Benson 1948; Gleason and Cronquist 1991; Keener 1976). In Pennsylvania, it is found in the southern third of the state (Wherry et al. 1979).

Besides noting *R. micranthus* on limestone in Franklin County, we have also seen it on soils derived from diabase in Adams County (Berg and Dodge 1981; Speir 1967) and shale in Franklin and Fulton counties (Berg and Dodge 1981; Berg et al. 1980). In degree of moisture, these sites range from the relatively mesic communities on limestone to the more xeric communities on shale. Most of the sites are on slopes of various aspects and degrees; only one is on level upland terrain. Our observations agree with published accounts on the range of parent materials and slopes that this species inhabits (Deam 1970; Keener 1976; Mohlenbrock 1981; Steyermark 1963). This species is known to be calciphilic in the Blue Ridge (Wofford 1989), and it is reported from diabase and floodplain soils in northern Virginia (Allard and Leonard 1962).

Fernald (1939) recognized two eastern varieties in this species on the basis of leaf morphology. Pennsylvania lies within the range of var. *delitescens* (Fernald 1950). Some subsequent authors have accepted this treatment (Fassett 1942; Steyermark 1963) while others have considered *R. micranthus* to be a single polymorphic taxon (Benson 1948; Keener 1976; Mohlenbrock 1981).

We have not satisfactorily distinguished *R. micranthus* from *R. abortivus* at some sites in southwestern Franklin County. These species are best identified in late April or early May; by early June, the aerial shoots shed their achenes, become lax, and disintegrate. Also, the two species are polymorphic and partly overlap in their diagnostic characters (Fernald 1950, Mohlenbrock 1981). Two of our herbarium specimens (Klotz 1236, Walck 7) exemplify the latter difficulty. Putative hybrids have been noted in southwest Ohio. These morphological intermediates occurred near the two parental species and were probably infertile (Blackwell 1977).

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[3] "Midland": *Carex amphibola, Trillium sessile, Dioscorea quaternata, Quercus muhlenbergii, Delphinium tricorne, Jeffersonia diphylla, Magnolia acuminata, Agrimonia rostellata, Vicia caroliniana, Oxalis grandis, Rhus aromatica, Euonymus atropurpureus, Matelea obliqua, Phlox divaricata, Phacelia purshii, Galium concinnum, Hedyotis nuttalliana* (as *H. purpurea* var. *tenuifolia*), *Aster shortii;* "Appalachian": *Penstemon canescens;* "Lowland": *Corallorhiza wisteriana, Krigia virginica, Lactuca floridana* var. *floridana.*

These two species possibly exhibit a partial ecological separation in some of the regions where they are sympatric. In southcentral Pennsylvania, we have observed both species on upland sites but only *R. abortivus* on floodplains. Similarly, along the Potomac River in Washington, DC and Maryland, *R. micranthus* tends to grow in more well-drained places than *R. abortivus* (Terrell 1970). In southwest Ohio, *R. micranthus* is confined to wooded slopes while *R. abortivus* is often weedy or adventive (Blackwell 1977).

We have not yet observed *R. allegheniensis,* a close relative of these two species, even though it has been reported from Franklin County (Wherry et al. 1979). According to Sobel (1974), *R. micranthus* and *R. allegheniensis* are perhaps merely ecological varieties of the polymorphic *R. abortivus,* at least in the Carolinas.

b. *Dodecatheon amethystinum* (Fassett) Fassett, jeweled shooting-star, is native to eastern and southcentral Pennsylvania. It also occurs along the upper Mississippi River in the "Driftless Area" of Wisconsin, Minnesota, and Iowa (Fassett 1944); and at scattered localities in Kentucky (Fassett 1944), western Illinois (Schwegman 1984), and central Missouri (Steyermark 1963). The closely similar *D. meadia* is widespread from Washington, DC to western Wisconsin, south to Georgia and Texas (Fassett 1944).

Both *D. amethystinum* and *D. meadia* have been reported from Pennsylvania, sometimes from the same location, as in Franklin and Columbia Counties (Wherry et al. 1979). However, the populations in eastern Pennsylvania are now considered to be *D. amethystinum* (R. Sutter pers. comm.; Fassett 1944). Although Fassett (1944) believed that both species might be occurring in the eastern panhandle of West Virginia, *D. meadia* is the only *Dodecatheon* currently reported from West Virginia (Strausbaugh and Core 1977), Maryland (Brown and Brown 1984), and Virginia (Harvill et al. 1986; Wofford 1989).

In Franklin County we have observed *D. amethystinum* in a calcareous rocky summit community on bluffs along West Branch Conococheague Creek, and at several sites in mesic calcareous upland forests. These habitats in Franklin County more nearly resemble those reported for *D. meadia* than those reported as most typical for *D. amethystinum.* Throughout its range, *D. meadia* inhabits meadows, railroad rights-of-way (Fassett 1931), mesic or dry prairies, open deciduous woods, oak openings, and wooded to open bluffs or cliffs. In contrast, *D. amethystinum* inhabits damp rock outcrops or earth slopes, deep ravines (Iltis and Shaughnessy 1960), moist crevices, and "steep slopes of north-facing wooded limestone bluffs" (Steyermark 1963). These situations agree with the habitat of *D. amethystinum* at sites in Lancaster and Columbia counties in Pennsylvania. However, in the Midwest this species also sometimes occurs on wooded slopes (Mohlenbrock 1978) or in small upland prairies (Iltis and Shaugnessy 1960). These situations resemble locations of *D. amethystinum* in Franklin County.

Both species are generally calciphilic throughout their respective ranges. *Dodecatheon amethystinum* occurs on limestone in Missouri (Steyermark 1963) and Wisconsin (Iltis and Shaughnessy 1960). In Illinois, it nearly always occurs on outcrops of limestone or dolomite; but a few populations are on outcrops of sandstone (Schwegman 1984). *D. meadia* is usually in basic or circumneutral soil in the Carolinas (Radford et al. 1968). It occurs on calcareous substrates in the Blue Ridge (Wofford 1989) and in Maryland (Boone 1984; Riefner and Hill 1984). In Ohio, it grows on dolomitic cliffs (Brockett and

Cooperrider 1983); and in central Tennessee, it occurs in calcareous woodlands and even in open cedar glades (Turner and Quarterman 1968). However, this species also occurs on serpentine in Maryland (Boone 1984) and on sandstone as well as "high lime" prairies in Wisconsin (Iltis and Shaughnessy 1960).

Dodecatheon amethystinum was initially described as a variety of *D. meadia* (Fassett 1929) and was later elevated to the rank of species (Fassett 1931). Subsequently, some authors have included it within *D. radicatum* Greene subsp. *radicatum* of western North America (Thompson 1953; Gleason and Cronquist 1991) despite morphological and ecological differences between it and this western taxon (Iltis and Shaughnessy 1960; Steyermark 1963).

Fassett (1944) considered the shape, thickness, and color of the capsule walls to be the most reliable characters for distinguishing *D. amethystinum* from *D. meadia* in both the field and herbarium. However, Schwegman (1984) showed that only the capsule wall thickness (measured in microns) is fully reliable; the shape and color exhibit overlap and variation.

Some of our recent field observations have exemplified the difficulty of distinguishing these two species. In April, 1991, the senior author observed *D. meadia* (with white corollas) in the Great Smoky Mountains National Park, Tennessee; the dried capsules from 1990 resembled *D. amethystinum.* In June, 1991, R. Bartgis showed us a large population of *Dodecatheon* (considered to be *D. meadia*) on the forested bluffs above the Potomac River near Sharpsburg, Maryland. The plants are known to have dark pink corollas (Bartgis pers. comm.) but had nearly mature fruit on the date of our visit. The shape of the capsules (Klotz, Bartgis, and Walck 1869) varies among the plants and apparently spans the alleged difference between the two species. We subsequently documented a similar array of variation in capsule shape in one of the populations in Franklin County (Klotz and Walck 1872). Our measurements of capsule wall thickness in these populations agree with the values reported for *D. amethystinum* (Fassett 1944).

The observed populations of *Dodecatheon* in Franklin County have pale to deep pink corollas, and some of the plants exhibit a degree of red pigmentation in the leaf bases. In these characters, the Franklin County populations resemble *D. amethystinum* more than *D. meadia* (Fassett 1944; Schwegman 1984). Both of these characters are unreliable in herbarium specimens. On drying, the corollas of the two species fade to the same range of colors; and the red pigmentation in the base of the leaves fades more in *D. amethystinum* than in *D. meadia* (Fassett 1944).

Possible hybrids have been collected in Wisconsin at a location where the two species occur in close proximity even though *D. amethystinum* blooms earlier than *D. meadia* by at least one week (Fassett 1931). Both species are pollinated by bees, including some of the same species of bumblebees (*Bombus* spp.). "The existence of genetic barriers to crossing remains to be demonstrated" (Macior 1970). Perhaps this possibility of hybridization in the Midwest is related to the indistinctness of these two species in the eastern part of their range. We believe that the populations in the Potomac River drainage of Pennsylvania, Maryland, West Virginia, and Virginia should be re-examined in fruit to determine whether they represent the same species.

c. *Rhamnus lanceolata* Pursh, lanceolate buckthorn, ranges from southcentral Pennsylvania to southern Wisconsin and Nebraska south to Alabama and eastern Texas (Brizicky 1964; Fernald 1950). This species is known from West Virginia (Strausbaugh and Core 1977) and northern Virginia (Harvill et al. 1986) but has not been reported from Maryland (Boone 1984; Brown and Brown 1972). Most of the records in Pennsylvania are from the southcentral counties west of the Susquehanna River (Wherry et al. 1979).

Although it is a large shrub, this species is not visually distinctive and is easily overlooked. It occurs in upland habitats such as bluffs, cliffs, rocky or gravelly wooded slopes, glades, and thickets; but it can also be found in springy places, fens, or floodplains (Deam 1970; Mohlenbrock 1982a; Steyermark 1963). We have not yet observed this species in a floodplain or other wetland but only in upland habitats, including a successional red cedar woodland described below, and a xeric upland forest. The species tends to be calciphilic (Braun 1961; Brizicky 1964; Deam 1970; Gleason and Cronquist 1991; Great Plains Flora Association 1986; Steyermark 1961).

Two varieties, perhaps merely "trivial" forms distinguished by pubescence (Johnston 1975), have been described within *R. lanceolata.* Variety *glabrata* predominates in the eastern and southeastern parts of the range of the species, but our specimen (Klotz 1254) fits var. *lanceolata,* which predominates in the western part of the range (Brizicky 1964).

Some descriptions suggest that the species is heterostylous (Fernald 1950; Mohlenbrock 1982a) or possibly functionally dioecious (Great Plains Flora Association 1986). We have not determined which floral morphs occur in the study area. The senior author has observed some plants in fruit in one of the populations.

d. *Matelea obliqua* (Jacq.) Woods., oblique milkvine, ranges from Pennsylvania to Missouri south to Georgia (Fernald 1950; Gleason and Cronquist 1991). In Pennsylvania it occurs sparsely throughout the southeastern and southcentral counties (Wherry et al. 1979).

We have observed three small populations of this species: two near the roadside edges of mesic calcareous forest, and another in an open, grassy area in successional red cedar woodland. At both sites *M. obliqua* grows in partial shade, which is the optimal condition for the vegetative growth of this species in cultivation (Rosatti 1989). Throughout its range, it occurs in woods, thickets, and riverbanks (Small 1933). However, the species of *Matelea* are reported to grow best in well-drained soils and do not occur in areas subject to flooding (Rosatti 1989). *Matelea obliqua* is known to be calciphilic in Maryland (Riefner and Hill 1984), North Carolina (Radford et al. 1968), the Blue Ridge (Wofford 1989), and the southeastern states in general (Rosatti 1989).

e. *Hydrophyllum macrophyllum* Nutt., large-leaved waterleaf, has two known populations in Franklin County, both in mesic calcareous forest. The larger population has been described previously (Klotz and Walck 1990). It occurs with *H. virginianum* in that community, and *H. canadense* is located on the nearby floodplain of Licking Creek.

f. *Ruellia strepens* L., limestone petunia, ranges from northcentral New Jersey to Iowa and Kansas south to South Carolina and eastern Texas (Fernald 1950; Gleason and Cronquist 1991). This species is frequent in southwestern Franklin County and along the Conodoquinet Creek in neighboring Cumberland County. There are four other records in Pennsylvania, all in the southern counties (Wherry et al. 1979). However, the species is easily overlooked. Our observation agrees with other authors that *R. strepens* occurs in upland forests, floodplain forests, and along mesic roadsides (Boone 1984; Deam 1970; Fernald 1950; Steyermark 1963). It is noted to be somewhat calciphilic (Allard and Leonard 1962; Boone 1984; Fernald 1950; Long 1970; Small 1933). The junior author has observed this species from shale in addition to limestone and alluvium in southwestern Franklin County.

We have seen chasmogamous flowers infrequently, chiefly in early June. The observed populations mostly appeared vegetative or belonged to "forma *cleistantha*" (Fernald 1950), which produces cleistogamous flowers that yield "numerous fruits with good seeds" (Long 1970). This so-called "form" is probably only a phase that develops during the latter part of the growing season. However, these two phases reportedly differ in leaf width and length. Differences between the cleistogamous and chasmogamous flowers include peduncle length, frequency of glands on the calyx-lobes, and size and form of the corolla—i.e. small and tubular in the cleistogamous flowers (Long 1970; McCoy 1937). The species is reported to be predominantly autogamous in the northern portion of its range (Long 1970). This situation possibly explains the infrequency of chasmogamous flowers in our observations.

g. *Chrysogonum virginianum* L., green-and-gold, ranges from southern Pennsylvania and eastern Ohio to western Florida and southern Mississippi (Gleason and Cronquist 1991; Stuessy 1977). The populations in Pennsylvania are reported from southern Franklin and Fulton Counties (Wherry et al. 1979) and from Lancaster County (Porter 1903). They compose part of the northeastern limit of the range of the species (Stuessy 1979). Specimens from the northern part of the range are mostly var. *virginicum,* which is cespitose and has well developed internodes. In the Carolinas, it gives way to var. *australe,* which is stoloniferous and has mostly basal leaves on the erect stems (Cronquist 1980; Steussy 1977). Morphological intermediates between these varieties have been collected throughout much of the total range, including southcentral Pennsylvania (Stuessy 1977).

The habitats of *Chrysogonum* throughout its range include rich woods, dry woods, and shaded rocks (e.g. Fernald 1950; Small 1933). In Maryland, the species is known to occur on limestone but is not restricted to it (Boone 1984). *Chrysogonum* occurs with *Dodecatheon amethystinum* at one location that we have observed. However, the two species occupy different microhabitats at this site: *Dodecatheon* chiefly occurs in grassy openings, which resemble the calcareous rocky summit community type described below, whereas *Chrysogonum* occurs in the shaded understory of the mesic upland forest.

h. *Corallorhiza wisteriana* Conrad, spring coral-root, ranges from Pennsylvania to Wisconsin and Kansas south to central Florida and eastern Texas. It also occurs in the Western Cordillera from southern Montana and eastern Idaho to southern Mexico, and in the Black Hills of South Dakota (Case 1987; Correll 1950). Most of the records in Pennsylvania are from southeastern counties, but one is southwestern (Wherry et al. 1979). In eastern North America this species is found in deciduous, mesic to xeric rich forests and swamp forests (Case 1987; Correll 1950; Sheviak 1974). In Indiana, this species grows on "beech slopes, sometimes in black or black and white oak woods, and rarely in white oak woods" (Deam 1970). It may grow mostly in circumneutral, nutrient-rich humus (Correll 1950 fide Wherry), but it is not restricted to limestone. In Illinois, the soils in which it grows are generally "moderately acidic" (Sheviak 1974).

Our two sightings of *C. wisteriana* were in the same community: one shoot in 1987 and a cluster of 15 shoots in 1991. This scarcity is not surprising. The species rarely occurs in colonies, and individuals are usually five meters or more apart (Deam 1970). The plants do not bloom every year, long periods may pass between blooming (Cusick 1984a), and populations vary annually in the number of individuals that bloom. Furthermore, the inflorescence is inconspicuous and is the only part of the plant above ground. The plants are essentially rootless and do not produce significant amounts of chlorophyll (Case 1987). Instead, they are dependent on a mycorrhizal fungus that envelops and invades the rhizome (Campbell 1970; Case 1987; Cusick 1984a). The prevention of trampling is especially important in the habitat of *Corallorhiza* because the mycorrhizal relationship makes it sensitive to soil disturbance (Cusick 1984a).

CALCAREOUS ROCKY SUMMIT COMMUNITY. This community type is characterized by conspicuous rock outcrops and a discontinuous canopy with herbaceous openings (PNDI

1983). We have observed two communities that somewhat approach this category. Both of them contain only one rare species. The community with *Opuntia humifusa* is artificial and not diverse: it occurs along the edge of a limestone quarry. In contrast, the community with *Dodecatheon amethystinum* appears natural and is species-rich: it consists of a suite of grassy openings in the calcareous upland forest on the crest of north-facing bluffs along the West Branch of the Conococheague Creek. In both of these rocky summit communities, the trees include *Juniperus virginiana* and *Celtis occidentalis;* but several other canopy species characteristic of calcareous upland forest (e.g. *Quercus muhlenbergii*) are present in the community with *D. amethystinum.* The latter community has considerable floristic and esthetic value. Similar rocky summit communities are reported in New York (Reschke 1990): "red cedar rocky summit community" (specified as calcareous), and "rocky summit grassland"; New Jersey (Breden 1989): a similar category, "traprock glade/rock outcrop community"; and Pennsylvania (PNDI 1983): "calcareous rocky summit community."

Opuntia humifusa (Raf.) Raf., prickly-pear cactus, ranges from Massachusetts to Iowa, south to Florida and Texas (Benson 1982). In Pennsylvania it occurs sparsely in the southern half of the state and along the Delaware River (Wherry et al. 1979). Throughout its range, it occurs on well-drained, exposed sandy soil and on rock outcrops, which include granite, sandstone, limestone, or shale (Benson 1982; Brown and Brown 1984). Distinctive community types that contain this species include shale barrens (Strausbaugh and Core 1977), cedar glades (Braun 1964; Baskin and Baskin 1978), and coastal dunes (Brown and Brown 1984). In New Jersey, it occurs on level terrain and on south (to southeast) slopes (Hanks and Fairbrothers 1969a). In Franklin County we have observed a large population of this species on shale and a small population on the forested brink and cliff face of a limestone quarry.

Two species were formerly recognized in Pennsylvania (Wherry 1926; Wherry 1964; Wherry et al. 1979): *O. calcicola* Wherry and *O. compressa* (Salis.) Macbr. Both are now considered conspecific with *O. humifusa* (Kartesz and Kartesz 1980), a polymorphic species (Hanks and Fairbrothers 1969b) exhibiting a high degree of morphological variability within populations (Romeo et al. 1987).

CALCAREOUS CLIFF COMMUNITY. This community type occurs on steep exposures and ledges of resistant, calcareous bedrock. Soil is nearly non-existent and the herbaceous vegetation is sparse and open (PNDI 1983). The degree of moisture ranges from mesic to xeric depending on aspect and cover. Similar communities have been described in New York (Reschke 1990) and Pennsylvania (PNDI 1983): "calcareous cliff community"; Maryland (Riefner and Hill 1984): limestone habitats one and two; and West Virginia (Core 1966): "limestone cliffs."

Mesic calcareous cliffs were observed in two types of locations. The first consists of small, vertical limestone outcrops in upland forest. We did not find any rare species on them. The second comprises wooded, north-facing bluffs along clearwater creeks, namely Licking Creek (in Pennsylvania and Maryland), Little Cove Creek, and the West Branch of the Conococheague Creek. Two rare species were observed on this type of mesic calcareous cliff: *Asplenium resiliens* and *Sedum telephioides.* On the rocky bluffs along Licking Creek, the two species occur in both Pennsylvania and Maryland. These two species plus seven others that we have observed in this community type in Franklin County are largely restricted to limestone or other basic and circumneutral substrates in Maryland: *Pellaea atropurpurea, Asplenium rhizophyllum, A. ruta-muraria, Cystopteris bulbifera, Arabis lyrata, Galium boreale,* and *Solidago flexicaulis* (Boone 1984; Riefner and Hill 1984).

The mesic calcareous cliff communities contain twelve species of epipetric ferns, including six species of *Asplenium*. The most constant are *A. platyneuron, A. rhizophyllum,* and *A. trichomanes,* which occur in five or all six examples of this community type that were tabulated. Their most constant associates are two herbaceous dicotyledons, *Aquilegia canadensis* and *Thalictrum dioicum.* The senior author discovered the county record of *Asplenium pinnatifidum* as a small population on a vertical limestone rockface in this region (Klotz 1767). This species usually inhabits non-calcareous rocks (Cobb 1956; Mickel 1979; Reed 1953) including sandstone (Lellinger 1985), and igneous and metamorphic outcrops (Wofford 1989).

Xeric calcareous cliffs also occur in southwestern Franklin County. We have observed two rare species on them: *Opuntia humifusa* on the edge and side of the limestone quarry described above in the calcareous rocky summit community, and one population of *Sedum telephioides* described below.

a. *Asplenium resiliens* Kunze, black-stemmed spleenwort, ranges from southcentral Pennsylvania to southern Nevada, south to the West Indies and northern Argentina (Lellinger 1985; Mickel and Beitel 1988; Small 1964). In Pennsylvania the species is known only from southwestern Franklin County (Wherry et al. 1979), which constitutes the northeastern limit of the range. This fern is an epipetric calciphile occurring on limestone, dolomite, and marl of cliffs, outcrops, and sinkholes (Gleason and Cronquist 1991; Lellinger 1985; Radford et al. 1968; Steyermark 1963). In the southeastern states it is noted as "preferring limestone, but also [occurring] on igneous rocks" (Small 1964).

Although *A. resiliens* is an apogamous triploid, it hybridizes with *A. heterochroum,* a species of Florida, Bermuda, and the West Indies (Lakela and Long 1976; Lellinger 1985). *Asplenium resiliens* is not known to hybridize with the Appalachian species of *Asplenium* even though the latter have produced a "complex" of hybrids and backcrosses (Lellinger 1985).

The populations of *A. resiliens* along Licking Creek occur in close proximity to *Sedum telephioides,* but the two species do not share the same microhabitats. In one instance, *S. telephioides* occurs fairly high on the bluffs, mostly on mesic but well-drained, sloping to vertical, forested rock faces. The adjoining stand of *A. resiliens* at this site occurs lower on the bluffs on moist, vertical rock faces. In the other instance, the two species are horizontally separated by about 200 meters. The *Sedum* occurs on an exposed grayish-red outcrop without an overarching canopy whereas the *Asplenium* occurs in shaded, moist crevices on forested bluffs.

b. *Sedum telephioides* Michx., Allegheny stonecrop, ranges from southern Pennsylvania to southern Illinois south to western South Carolina (Clausen 1975). It is also reported from New York, but these populations are other, misidentified species of *Sedum* except one which may represent an escape from cultivation (Clausen 1975; Spongberg 1978). In Pennsylvania the plant is restricted to six known sites in Bedford, Fulton, and southwestern Franklin Counties. All but one are near the Maryland border (Wherry et al. 1979) and represent the northeastern limit of the species.

Sedum telephioides occurs on dry, rocky ledges; exposed or shaded cliffs; rocky woods; rock crevices; and steep bluffs (Mohlenbrock and Voigt 1959; Gleason and Cronquist 1991; Radford et al. 1968; Spongberg 1978). It is not a calciphile, but is known from greenstone, gneiss, granite, sandstone, shale, and slate in addition to limestone (Clausen 1975). It occurs on sandstone outcrops and shale barrens in West Virginia (Strausbaugh and Core 1977), on limestone and shale outcrops in Maryland (Riefner and Hill 1984), and on sandstone and limestone cliffs in Indiana (Deam 1940; Spongberg 1978). At one of the two sites in Fulton County, PA, the species occurs on a south-facing bluff of reddish rock of the Catskill Formation, "a complex unit consisting of shale, siltstone, sandstone, and conglomerate" (Geyer and Wilshusen 1982). The community at this site combines species of the acidic and calcareous cliff community types (PNDI 1983). The other population in Fulton County occurs in a shale barren community on calcareous Devonian shale (Cusick 1990). It also grows on shale barrens in Bedford County (Henry 1978). One of the two populations in Franklin County occurs sympatrically with *S. ternatum.*

FLOODPLAIN FOREST. Floodplain forests are hardwood forests on mineral soils of low terraces along rivers and creeks that flood periodically (PNDI 1983). The following species of canopy trees were observed in three or more of the five examples that were tabulated: *Platanus occidentalis, Ulmus americana, Carya cordiformis, Juglans nigra, Acer negundo, A. saccharinum,* and *Fraxinus americana* and/or *F. pennsylvanica.* The shrubs and vines with this degree of constancy include: *Lindera benzoin, Rosa multiflora, Rubus* spp., *Cornus amomum, Vitis vulpina,* and *Toxicodendron radicans.* The herb layer is commonly luxuriant and diverse. The examples of this community type containing rare species occur along Licking Creek and the West Branch of the Conococheague Creek. The floodplain forests in our study area are floristically similar to those described in New York (Reschke 1990), New Jersey (Breden 1989), Pennsylvania (PNDI 1983), West Virginia (Core 1966): "floodplain forest"; Maryland (Brush et al. 1980): "sycamore–green ash–box elder–silver maple association"; and Virginia (Harvill et al. 1977): "floodplain forest," (Rawinski 1990): "eutrophic seasonally flooded palustrine system."

The rare species that we have observed are *Ruellia strepens* (discussed above) and *Ptelea trifoliata.* They and four other species that we have seen in this community type are generally restricted to limestone or other basic to circumneutral soils in Maryland: *Carya laciniosa, Hydrophyllum canadense, Arisaema dracontium,* and *Carex shortiana* (Boone 1984; Riefner and Hill 1984).

Ptelea trifoliata L., common hop-tree, occurs from Connecticut and southern Quebec to Nebraska, south to Florida and northern Mexico, and west to Arizona (Fernald 1950; Gleason and Cronquist 1991). Our specimens belong to subsp. *trifoliata* var. *trifoliata.* In Pennsylvania, the species is known from a few localities, mostly in the southeastern counties and along Lake Erie (Wherry et al. 1979). It occurs in a wide range of habitats including alluvial and upland rocky woods, swamps, glades, prairie openings, dry bluffs, thickets, fencerows, sandy fields, and wooded to open dunes along the Great Lakes (Billington 1949; Radford et al. 1968; Steyermark 1963; Voss 1985). Along the north shore of Lake Erie, it especially occurs on the windward side of beaches and sandspits (Ambrose et al. 1985). It is known to be calciphilic in Maryland (Boone 1984; Riefner and Hill 1984), Missouri (Steyermark 1963), and the Great Plains (Great Plains Flora Association 1986); and it is often in limestone areas in southern Illinois (Mohlenbrock 1982b) and southern Ontario (Ambrose et al. 1985).

In 1985, we observed ten trees of *P. trifoliata* on the floodplain along the north bank of Licking Creek. Some of them were two to three meters tall, but we observed no saplings or seedlings. In 1990, we observed only two of these trees; and they appeared unhealthy. We also found one tree of *P. trifoliata* along the south bank.

The species is predominantly dioecious, rarely polygamous (Ambrose et al. 1985; Brizicky 1962). In Ontario, the sex ratio of native populations is skewed toward the males (Ambrose et al. 1985). We have observed both sexes in the local population, but we have not determined the sex ratio. Despite the potential for root sprouts (Brizicky 1962), the species is not clonal and depends on seeds for establishment. However, flowering and fruiting are reduced or suppressed by shading (Ambrose et al. 1985).

SUCCESSIONAL RED CEDAR WOODLAND. Our three examples of this community type occur in different situations: an abandoned field and pasture, a powerline cut, and the cleared areas around a limestone quarry. The first of these is the most extensive and possibly the oldest. It occurs on karst terrain with a mosaic of vegetation: an upland savanna dominated by *Juniperus virginiana* surrounds numerous sinkholes that support closed deciduous forest. The ground layer of the savanna contains the rare elements *Ruellia humilis, Rhamnus lanceolata, Matelea obliqua, Bouteloua curtipendula,* plus many other herbaceous and woody species. The sinkholes support "islands" of mixed deciduous forest with a canopy that includes *Celtis occidentalis, Ulmus rubra, Carya ovalis, Quercus muhlenbergii, Q. rubra, Prunus serotina, Acer negundo,* and *Fraxinus americana.* Communities that are similar to the red cedar woodlands of Franklin County have been described in New York (Reschke 1990): "successional red cedar woodland"; New Jersey (Breden 1989): "limestone glade"; Pennsylvania (Duppstadt 1972): "cedar barrens," (PNDI 1983): intermediate between "successional field" and "young miscellaneous forest"; Virginia (Rawinski 1990): "oligotrophic scrub" or, as the trees grow taller, "oligotrophic woodland"; and West Virginia (Bartgis 1985): "limestone glade"; (Core 1966): intermediate between "artificial prairies" and "red cedar forest type."

The cedar glades of the unglaciated eastern United States can be defined as communities of low herbaceous vegetation with "limestone or dolomite bedrock at or near the surface" (Baskin and Baskin 1986). The soils are very shallow or restricted to crevices, saturated from late autumn through early spring, and droughty during the remainder of the year (Baskin and Baskin 1974). Slightly deeper soils support cedar barrens, which are forest openings dominated by mid-to-tall, native perennial grasses (DeSelm 1989; Quarterman 1989). Franklin County lacks the extensive bedrock pavement that characterizes the cedar glades of the Ridge and Valley Province from West Virginia to Alabama; the Interior Low Plateaus of Kentucky and Tennessee to southern Ohio, Indiana, and Illinois; and the Ozark region (Baskin and Baskin 1986). However, some of the successional woodlands on limestone in Franklin County resemble the cedar barrens of these regions in having shallow soils and several of the characteristic species, including *Juniperus virginiana, Ophioglossum engelmannii, Ruellia humilis,* and *Bouteloua curtipendula* (Baskin and Baskin 1974; DeSelm 1989).

Before European settlement in the mid eighteenth century, the limestone regions of the Great Valley in Franklin County contained luxuriant grasslands, which were called "barrens" because of the scarcity of trees (Finafrock 1942; M'Cauley 1878; Orr 1904). The extensiveness of these grasslands has been debated (Cooper 1903). They were maintained annually by the Indians in November, when "the woods and grass of the mountains and prairies were burned and their game was driven from concealment" (Richard 1887). The practice of burning ceased after European settlement; and within less than a century, the grassland developed into forest, most of which was cleared during the nineteenth century (Orr 1904).

The prairies that formerly occupied the Big Barrens region of Kentucky may have had a similar origin. The karstic topography helped to dry the soil and was therefore conducive to fire. After the Indians ceased to burn the vegetation, "the swift return of the forests . . . caused a large part of this prairie country to be rewooded before it could be subjected to the plough" (Baskin and Baskin 1981). The prairies of the Middle West have had a similar history except that the period of reforestation began much later, e.g. after 1860 in Illinois (Gleason 1922).

In southwestern Franklin County, the presence of unusual native flora on karst topography suggests that some examples of red cedar woodland may be relics of the former grassland vegetation. Of course, many stands of red cedar woodland in this region are simply the result of recent secondary succession on agricultural land. For example, in Bedford County, Pennsylvania, "cedar barrens" have developed as *Juniperus virginiana* has spread in heavily pastured areas on limestone soils, sometimes in association with *Cercis canadensis.* The herbaceous plants are suppressed by grazing (Duppstadt 1972). The presence of *Juniperus virginiana* indicates the absence of burning since the thin bark and the roots near the soil surface are injured by light surface fires (Fowells 1965). In this respect, red cedar woodlands differ from the midwestern oak savannas and "barrens," in which the characteristic woody species are more tolerant of fire. However, in all of these community types, burning would enhance the native prairie species such as *Ruellia humilis* and *Bouteloua curtipendula* (Anderson 1981; Anderson 1982; Anderson and Schwegman 1991; Curtis 1959).

The four rare species that we have observed only in this community type are *Ophioglossum engelmannii, Salvia reflexa, Ruellia humilis,* and *Bouteloua curtipendula.* In addition, we have seen *Rhamnus lanceolata* and *Matelea obliqua,* which also occur in calcareous upland forest. Five of the species that we have seen in this community type are generally restricted to limestone or other basic to circumneutral soils in Maryland: *Matelea obliqua, Trichostema brachiatum, Ruellia humilis, Eupatorium altissimum,* and *Bouteloua curtipendula.* We have also seen *Panicum flexile* and *Sporobolus neglectus* in this community type. These two grasses are "endangered" in Maryland but are not yet known from limestone in that state (Boone 1984; MNHP 1991; Riefner and Hill 1984; Bartgis pers. comm.).

a. *Ophioglossum engelmannii* Prantl, Engelmann's adder's-tongue, was discovered in June 1990 for the first time in Pennsylvania and represents the known northern limit of the range of the species (Walck and Klotz 446 PH). Otherwise, it ranges from northern Virginia to Kansas and Arizona south to Florida and southern Mexico (Fernald 1950; Mickel and Beitel 1988). It is not known to occur in Maryland (Boone 1984) but was collected in 1989 in a glade woodland on dry limestone in Hardy County, West Virginia (Bartgis 1252 PH). This species is calciphilic: it inhabits soils derived from limestone or calcareous shale in pastures, barrens, cedar glades, and open woods (Baskin and Baskin 1974; Cusick 1984b; Lellinger 1985; Mickel and Beitel 1988; Wherry 1961; Wofford 1989). In Illinois, it is restricted to limestone ledges whereas *O. vulgaris* occurs in moist woods and shaded sandstone ledges (Mohlenbrock 1967). In the Great Plains, it occurs on shallow soil over limestone and rarely on sandstone in prairies, pastures, or open woods (Great Plains Flora Association 1986).

The population in Pennsylvania occurs in an upland portion of a powerline cut through a deciduous forest. The population is limited but dense and occurs within an area of four square meters. The visible part consisted of 69 fertile leaves plus 149 vegetative leaves. The species is known to be clonal: the roots grow horizontally and produce adventitious buds, which produce new shoots. The short, vertical rhizomes produce one or two, rarely three leaves during a growing period (Baskin and Baskin 1974; Shaver 1954). After summer droughts the leaves die, but a reduced number of new ones appear in late summer or fall following rainy periods (Steyermark 1963; Baskin and Baskin 1974). Because the fronds wither quickly after the spores are released, the populations can be located only within a limited period (Cusick 1984b).

Population studies of this species differ markedly in the reported percentages of plants with fertile leaves (Baskin and Baskin 1974; Shaver 1954; Steyermark 1963). These discrepancies suggest that populations may differ in vigor or may vary in vigor from year to year because of differences in soil moisture (Baskin and Baskin 1974).

b. *Salvia reflexa* Hornem., lance-leaved sage, ranges from Ohio and Michigan to Montana and Utah, south to Arkansas and Mexico. It is sometimes adventive in the northeastern United States (Fernald 1950; Gleason and Cronquist 1991) and southern Canada (Scoggan 1978–1979). In Pennsylvania, it is known from a few scattered locations in the southern half of the state (Wherry et al. 1979)—for example, in ballast and on curbing in Lehigh County (R.L. Schaeffer 99984, 100033, 101149). It is recorded from one location in Maryland (Hill 1988) and is sparingly established in West Virginia (Strausbaugh and Core 1977). In Indiana, it is established in disturbed sandy soil in a few locations (Deam 1970). Throughout its range it occurs in disturbed habitats including dry pastures, roadsides, railroads, fields, wash areas in prairies, dry rocky open ground, open woods, and alluvial ground (Great Plains Flora Association 1986; Steyermark 1963). *Salvia reflexa* shows no indication of being calciphilic. Nevertheless, our single site for this species is close to a limestone quarry. The immediate vegetation is highly disturbed and consists largely of two aggressive, non-native species: *Ailanthus altissima* and *Lonicera japonica.*

c. *Ruellia humilis* Nutt., fringed-leaved petunia, ranges from Pennsylvania to Nebraska south to western Florida and Texas (Gleason and Cronquist 1991; Long 1970). In Pennsylvania, it is only known from Franklin County (Wherry et al. 1979). Throughout its range, it occurs in open fields, dry prairies, glades, dry or rocky woods and the escarpment of bluffs (Great Plains Flora Association 1986; Long 1970; Steyermark 1963). It is present in cedar glades of the Big Barren region of Kentucky (Baskin and Baskin 1981). In southern Illinois, it occurs in the upland grass communities called hillside prairies, which are on the crest of bluffs, especially limestone, that border the Mississippi River (Evers 1955; Voigt and Mohlenbrock 1964). It also occurs in similar communities in Ohio and Indiana (Gordon 1969). This species is known to be calciphilic in Maryland where it "grows in dry woods and basic habitats that simulate prairies" (Riefner and Hill 1984).

Ruellia humilis is morphologically variable. Two to five varieties have been recognized (Fernald 1950; Gleason and Cronquist 1991), but their importance is doubtful (Long 1970). Our specimen (Klotz 1253) combines the characters that are supposed to separate var. *humilis* and var. *frondosa* Fern., the two varieties that have been reported from Pennsylvania (Fernald 1950). In some parts of its range, *R. humilis* intergrades morphologically with *R. caroliniensis;* and these two species can hybridize (Long 1961).

Like *R. strepens, R. humilis* can produce cleistogamous flowers (Fernald 1950); but we have observed that it also produces abundant chasmogamous flowers. We have not found *R. strepens* and *R. humilis* growing sympatrically; *R. humilis* occurs in more open habitat. We have observed *R. humilis* in two of the red cedar woodlands described above, namely the disturbed vegetation surrounding a quarry and the more mature vegetation on karst terrain.

d. *Bouteloua curtipendula* (Michx.) Torr., tall grama, ranges from Maine to southern Saskatchewan south to Georgia, southern California, and Argentina (Fernald 1950; Hitchcock 1971; Scoggan 1978–1979). In Pennsylvania, it occurs in a few localities in the southcentral and eastern counties (Wherry et al. 1979). It is one of the chief grasses of the prairies of the midwestern states (Curtis 1959; Weaver 1968) and can dominate the xeric extreme of the topographic moisture gradient (Bazzaz and Parrish 1974). It is frequent on limestone glades, barrens, and prairie openings in rocky woodlands in Missouri (Steyermark 1963) and southwestern Virginia (Carr 1965). It is absent from the cedar glades of Kentucky but is present in cedar glades in Tennessee, Alabama, and Georgia (Baskin and Baskin 1981 and pers. comm.). In Ohio, Indiana, and Illinois, the species is important in the upland grass communities or hillside prairies that were mentioned above for *Ruellia humilis* (Deam 1970; Evers 1955; Gordon 1969; Voigt and Mohlenbrock 1964). It occurs on serpentine barrens in southeastern Pennsylvania (Braun 1964; Pohl 1947; Rhoads 1986; Wherry et al. 1979); shale barrens in Maryland (Morse 1984) and West Virginia (Strausbaugh and Core 1977); and dry, open calcareous slopes in New Jersey (Snyder 1986), Pennsylvania (T. Smith pers. comm.), Maryland (Boone 1984; Riefner and Hill 1984), and West Virginia (Bartgis 1985; Strausbaugh and Core 1977). In our study area it occurs with *R. humilis* on the karst terrain described above.

EARLIER RECORDS OF RARE PLANTS ON LIMESTONE IN SOUTHWESTERN FRANKLIN COUNTY

Thomas C. Porter, author of the *Flora of Pennsylvania* (1903), collected plants in Franklin County in the 1850s and recognized the distinctiveness of its flora within the state. We have observed four of the species that he considered "rare" or "peculiar" at that time: *Rhamnus lanceolata, Matelea obliqua* (as *Gonolobus obliquus*), *Ruellia strepens* (as *Dipteracanthus strepens*), and *Chrysogonum virginianum* (Porter 1872).

Besides the 16 species described above, 11 additional "Species of Special Concern" (PNDI 1991) have been collected previously in southwestern Franklin County (Wherry et al. 1979—except *Clematis viorna,* which was noted by Porter 1872) and are likely to be associated with calcareous substrates there. They can be classified into three categories of habitat:

(1) RICH WOODS AND BOTTOMS. *Clematis viorna* (Boone 1984; Radford et al. 1968; Riefner and Hill 1984; Steyermark 1963). *Quercus shumardii* (Boone 1984; Fernald 1950; Small 1933; Waldron et al. 1987; also on rocky slopes and in swamps—Grimshaw and Bradley 1973). *Spiranthes ovalis* (Boone 1984; Fernald 1950; Riefner and Hill 1984; also in disturbed sites: abandoned fields and pastures, edges of woods and thickets, wooded soil bank of a strip mine—Sheviak 1974).

(2) PRAIRIES AND DRY, OPEN WOODS. *Ranunculus fascicularis* (Boone 1984; Fernald 1950; Keener 1976; Riefner and Hill 1984; Wofford 1989).[4] *Onosmodium hispidissimum* (Baskin and Baskin 1986; Boone 1984; Fernald 1950; Riefner and Hill 1984; Strausbaugh and Core 1977). *Pycnanthemum torrei* (Riefner and Hill 1984). *Solidago rigida* (Radford et al. 1968; Snyder 1986).

(3) WETLANDS (POSSIBLY MARL WETLANDS). *Juncus brachycephalus* (Boone 1984; Deam 1970; Fernald 1950). *Carex buxbaumii* (Bartgis and Lang 1984; Deam 1970; Small 1933; Steyermark 1963; Voss 1972). *Carex lasiocarpa* (Bartgis and Lang 1984; Voss 1972). *Carex tetanica* (Bartgis and Lang 1984; Boone 1984; Deam 1970; Fernald 1950; Keener and Park 1986; Rhoads 1989; Riefner and Hill 1984; Westerfeld 1961).

Additional examples of the first two community types remain to be explored in southwestern Franklin County, and most of the sites that we have examined still lack a complete floristic survey conducted over the entire growing season. Calcareous wetlands remain to be discovered and described in this region, but marl deposits are present: they are associated with the Warner soil series (Long 1975). Marl wetlands like those of the Great Valley Province in eastern West Virginia (Bargis and Lang 1984) could contain some of the wetland species listed above. Besides the eleven historic species that remain to be rediscovered on limestone in southwestern Franklin County, additional rare species associated with limestone are known from the neighboring portions of Maryland (Boone 1984; Riefner and Hill 1984), eastern West Virginia (Bartgis 1985; Bartgis and Lang 1984), and other parts of southern Pennsylvania (e.g. *Pachistima canbyi*—Duppstadt 1972; Wherry et al. 1979). Also, the hybrids and backcrosses of the "Appalachian *Asplenium* complex" (Lellinger 1985) could be present in this region. All of these taxa should be sought in southwestern Franklin County.

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[4] After this paper was completed, John Kunsman informed us that he had recently rediscovered a historical population of this species on limestone bluffs along the Conococheague Creek in Franklin County.

SUMMARY

Sixteen species of vascular plants that are rare (i.e. "Plants of Special Concern") in Pennsylvania are currently known from calcareous soils or outcrops in southwestern Franklin County: *Ophioglossum engelmannii, Asplenium resiliens, Ranunculus micranthus, Opuntia humifusa, Dodecatheon amethystinum, Sedum telephioides, Rhamnus lanceolata, Ptelea trifoliata, Matelea obliqua, Hydrophyllum macrophyllum, Salvia reflexa, Ruellia humilis, R. strepens, Chrysogonum virginianum, Bouteloua curtipendula,* and *Corallorhiza wisteriana.* For each of these species, the habit, habitat, range, and rarity are described; and the literature on intraspecific variation, breeding system, and hybridization is summarized. Each population is characterized according to physiographic section, geologic formation, elevation, soil mapping unit, slope, community type, shading, area, and number of aerial shoots. Additional species are listed that have been collected historically in this region, probably from calcareous substrates. Floristic information is provided on the communities and community types on calcareous substrates in southwestern Franklin County: upland forest, rocky summit, cliff, floodplain forest, and red cedar woodland. The flora of one mesic upland forest community is analyzed in detail.

ACKNOWLEDGMENTS

We are grateful to the following residents of Franklin County for their congenial cooperation in this project. Mr. Robert Hunter discovered the three known populations of *Dodecatheon amethystinum* in the vicinity of Licking Creek and the second population of *Hydrophyllum macrophyllum* in that area. Mr. Charles Brightbill provided several leads: the rich, calcareous slope along Licking Creek (described by Klotz and Walck 1990); *Asplenium resiliens* along Little Cove Creek; and *Dodecatheon amethystinum* along the West Branch of the Conococheague Creek. Mr. and Mrs. John J. McCulloh and family, Mrs. Margaret Weller, Mr. and Mrs. Harry Heinbaugh, and the owners of Valley Quarries, Inc. personally granted us access to their respective properties.

We also thank all of the following persons and agencies for their assistance and support in this project. Thomas Smith, Phillip de Maynadier (both formerly of PNDI), Dr. Roger Latham (The Nature Conservancy, Philadelphia Office), and Dr. Ann Rhoads (Morris Arboretum, University of Pennsylvania) accompanied us in some of our field work. The Pennsylvania Natural Diversity Inventory provided copies of their pertinent field reports. Botanists and ecologists of the natural heritage programs in the surrounding states contributed current editions of their rare plant listings and community classifications:

Steve Young (New York), David Snyder (New Jersey), Keith Clancy (Delaware), Gene Cooley (Maryland), Chris Ludwig and Tom Rawinski (Virginia), P.J. Harmon (West Virginia), and Allison Cusick (Ohio). Robert Sutter (Southern Heritage Task Force) annotated our initial collections of *Dodecatheon.* Charles Bier (Western Pennsylvania Conservancy) provided data on *Sedum telephioides* in western Pennsylvania. Drs. Jerry and Carol Baskin (University of Kentucky) provided information on *Bouteloua curtipendula* in the cedar glades. Dr. Alfred E. Schuyler (Academy of Natural Sciences), Dr. Carl Keener (Pennsylvania State University), Rodney Bartgis (Maryland Natural Heritage), and Dr. Ann Rhoads (Morris Arboretum of the University of Pennsylvania) provided helpful suggestions on the manuscript. Shippensburg University provided the use of a microcomputer and the support for numerous interlibrary loans and computerized bibliographic searches (DIALOG).

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Bartonia No. 57, Supplement: 42–49, 1993

Designing and Implementing a Riverine Preserve for the Endangered *Ptilimnium nodosum:* Sideling Hill Creek as a Case Study

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A frequent criticism of research and recovery efforts for endangered species is that they tend to focus on a single species and consequently fail to address concerns about other species or functions of the landscape in which that species occurs (Grumbine 1990, Hutto et al. 1987). Landscape and ecosystem features may often be critical to long-term persistence of the critical microsite. Consequently, even if a protection strategy focused on a single species is pursued, a broader view of habitat may be warranted.

Endangered riparian plant species exemplify these issues and therefore are particularly difficult to protect. Events critical to the survival of the species may occur at considerable distances from individual plants. Also, and perhaps consequently, riparian populations and habitats are often dramatically dynamic (Bowles and Apfelbaum 1989, Menges 1990). We suspect that such remote, ecosystem-level effects on populations probably occur in many habitats; in riparian systems they may simply be more dramatic and apparent.

Recent studies we have completed on the demographics, life history and habitat requirements of the endangered riparian plant *Ptilimnium nodosum* demonstrate the importance of landscape scale factors to the conservation of endangered species. In this paper we will discuss Sideling Hill Creek, MD, and its population of *Ptilimnium,* as a case study to encourage similar approaches elsewhere.

Sideling Hill Creek is a 40 km long stream which originates in Bedford and Fulton counties, PA, and flows south forming the boundary between Allegany and Washington counties, MD. It meets the Potomac River about 130 km northwest of Washington DC. Approximately 80% of the watershed in Maryland is forested, agricultural or residential use is limited. The stream is within the Ridge and Valley physiographic province and, in Maryland, crosses Devonian shales and sandstones of the Chemung and Hampshire formations as well as Quaternary alluvium and terrace gravels (Edwards 1978). The topography is rolling to steep over much of the watershed. In Maryland, the stream elevation drops from 204 m at the Pennsylvania line to 125 m at the Potomac; the highest Maryland elevation in the watershed is 536 m.

Ptilimnium nodosum is a short-lived member of the Apiaceae. It occurs in riparian and wetland habitats in Maryland, West Virginia, North Carolina, Georgia, Alabama and Arkansas. It was listed as an endangered species by the federal government in 1988 because of habitat loss from destruction of wetlands, impoundments, shoreline development, and declines in water quality (US Fish and Wildlife Service 1988). In the Potomac River watershed the species is currently known only from Sleepy Creek and the Cacapon River in West Virginia and Sideling Hill Creek and Fifteen Mile Creek in Maryland.

Historically it also occurred along the Potomac River in Maryland and probably along the Shenandoah River in West Virginia (US Fish and Wildlife Service 1991).

PTILIMNIUM LIFE HISTORY AND DEMOGRAPHICS

In 1988 we initiated a series of studies on the life history, demographics, and habitat of *Ptilimnium nodosum* in order to better define threats to the species and conservation needs. Here, we briefly review those findings which are guiding habitat protection efforts on Sideling Hill Creek.

Ptilimnium occurs along the stream in relatively discrete stands of one plant to thousands. Distribution is not uniform, with some areas supporting many stands and other areas having hundreds of unoccupied meters between stands. *Ptilimnium nodosum* occupies cobblestone shoals, gravelbars, and bedrock outcrops which are seasonally flooded but above water for part of the summer. Shoals co-dominated by *Justicia americana* support the largest stands of *Ptilimnium,* but *Ptilimnium* is restricted to a much narrower range of water depth than *Justicia* (Maddox and Bartgis 1992), indicating the species is poorly suited to changes in stream flow. *Ptilimnium* is usually absent from areas with significant silt accumulation. Both field transplant studies and greenhouse experiments indicate that sedimentation can reduce the vigor and success of *Ptilimnium* (Maddox and Bartgis unpublished data).

In July, about when water levels are lowest, *Ptilimnium* plants develop new basal leaves and flower from leafy stems 10 to 50 cm tall. By September the seeds germinate, either on the inflorescence or after falling. During high water levels in late summer flowering plants are knocked over by the flowing water. Rootlets and leafy shoots form at nodes of repent flowering stems, providing for asexual recruitment. Although asexual recruitment appears to occur frequently, sexual recruitment rates vary from year to year in response to water regimes. During the winter young and adult *Ptilimnium nodosum* persist under water as basal rosettes, although stands may be exposed briefly during periods of low water (Maddox and Bartgis 1989, 1992).

Stand size distribution is considerably skewed. Over a third of all stands are small (less than a hundred individuals), although big stands (over 1000 individuals) are not uncommon. We monitored 56 locations along Sideling Hill Creek which supported a stand of *Ptilimnium* for at least one year during the period 1988–1990. During this period the number of stands increased, but the mean stand size stayed about the same. However, only 43% of the locations with stands in 1988 had stands in 1990. Nearly all stands which were lost during this period were small, with fewer than 100 individuals (Maddox and Bartgis 1992). Overall, the population of *Ptilimnium nodosum* on Sideling Hill Creek is relatively large and stable, with an estimated total population size of 25,000 to 35,000 individuals during the study period.

OTHER BIODIVERSITY CONCERNS

In addition to the large population of *Ptilimnium,* the Sideling Hill Creek valley is also noteworthy for other biological diversity resources. The creek and its surroundings support a number of rare species populations and high quality natural communities in both Maryland and Pennsylvania (Table 1). In both states the slopes adjacent to the stream include mid-Appalachian shale barrens, which support a number of endemic plants (Keener 1983). In Maryland the Sideling Hill Creek barrens support a variety of state endangered and threatened plants, including *Prunus allegheniensis, Woodsia ilvensis, Melica* *nitens, Adlumia fungosa, Minuartia michauxii,* and the endemics *Trifolium virginicum* and *Taenidia montana.* The adjacent diverse forest communities also support a variety of threatened and endangered species including *Polygala polygama,* and the only known Maryland population for the Appalachian endemic *Calamagrostis porteri* (Bartgis 1991). Floodplain forests support *Cacalia suaveolans* and the largest population known in the state of *Iris cristata.* The upland and many of the floodplain forests along the creek are remarkably free of alien weeds.

Sideling Hill Creek itself is relatively unpolluted (Duigon and Dine 1991) and supports a diverse native freshwater mussel fauna including the largest population known in the state of the globally uncommon *Lasmigona subviridus,* the globally uncommon *Elliptio producta,* and several other state-rare mussels (Table 1).

Farther east in Maryland upland forests have been heavily fragmented by human land-use patterns, resulting in a decline in bird species which require large blocks of forest land to maintain viable breeding populations (Whitcomb et al. 1981). The Sideling Hill Creek watershed includes some of the largest blocks of unbroken forest in this part of Maryland. Most forest-interior dwelling bird species of the Ridge and Valley breed in the area.

CONSERVATION ISSUES

Realistically, certain potential goals of landscape-level conservation are not attainable. For example, corridors connecting areas of suitable habitat have been suggested for several reasons, including maintaining movement pathways in anticipation of long-term climate change (Hunter et al. 1988). Unfortunately, it is unlikely that a corridor which effectively connects Sideling Hill Creek with other streams can be created since experimental transplants suggest that the Potomac River no longer provides suitable habitat for the species (Maddox and Bartgis 1989).

The high turn-over rates among *Ptilimnium nodosum* stands indicate that protection efforts aimed at protecting specific stands, especially smaller ones, will probably be unsuccessful. Although turn-over rate may vary among streams, we suspect that they will be fairly high in most streams within the Potomac watershed. On Sideling Hill Creek, less

TABLE 1. Rare species of the Sideling Hill Creek watershed in Maryland. Status ranks are defined by Maryland Natural Heritage Program (1991a, 1991b), except for mussels which are partially based on more recent information.

Butterflies: *Satyrium edwardsii* (State Endangered); *Euchloe olympia* (State Rare); and *Fixsenia ontario* (State Endangered).

Mussels: *Alasmidonta undulata* (State Rare); *Alasmidonta varicosa* (State Endangered, Federal Candidate); *Lasmigona subviridus* (State Endangered, Federal Candidate); *Elliptio producta* (State Rare); and *Strophitus undulatus* (State Rare).

Vertebrates: *Neotoma floridana* (In Need of Conservation (State), Federal Candidate); and *Dendroica fusca* (State Threatened).

Plants: *Adlumia fungosa* (State Threatened); *Amelanchier spicata* (State Threatened); *Astragalus canadensis* (State Endangered); *Cacalia suaveolans* (State Endangered); *Calamagrostis porteri* (State Endangered); *Calystegia spithamaea* (State Rare); *Carya laciniosa* (State Endangered); *Cyperus houghtonii* (Status Uncertain, State); *Euphorbia obtusata* (State Endangered); *Iris cristata* (State Endangered); *Liatris turgida* (State Endangered); *Melica nitens* (State Threatened); *Minuartia michauxii* (State Threatened); *Polygala polygama* (State Threatened); *Polygala senega* (State Threatened); *Prunus alleghaniensis* (State Endangered); *Ptilimnium nodosum* (State Endangered, Federal Endangered); *Solidago hispida* (State Endangered); *Stellaria alsine* (State Endangered); *Taenidia montana* (State Threatened); *Trifolium virginicum* (State Threatened); *Woodsia ilvensis* (State Threatened); and *Zanthoxylum americanum* (State Endangered).

than half of the locations which supported *Ptilimnim nodosum* contained plants all three years of the study. While large stands are more stable, they are occasionally lost, or may decline through time. A stand on Sleepy Creek, WV, declined from over 100,000 individuals in 1983 to about 10,000 individuals in 1986. Although *Ptilimnium* populations have not been tracked through major storms (see below), it is likely that even large stands are at risk of being lost during such events.

Small stands, however, probably play significant roles in overall population dynamics. Small stands are not just less "successful" stands, they also include pioneering stands which may become larger through time. For example, on Sideling Hill Creek, stands which had only about 40, 60, and 100 individuals in 1988 had grown to support about 150, 750, and 1100 individuals, respectively in 1990.

Habitat characteristics at a given site change through time as deposition and erosion alter shoal and gravelbar areas. These events result in changes in the distribution of *Ptilimnium* habitat. On Sideling Hill Creek, some sections of the creek are entrenched, with little or no floodplain, and the channel has limited options for movement. Other sections are on a well-developed floodplain and have undergone substantial changes in channel location through time. *Ptilimnium* occurs in both landforms: stands are slightly more frequent in entrenched sections but typically largest where there are well-developed floodplains (Maddox and Bartgis 1992).

In 1985 Hurricane Juan had devastating effects on streams further upstream in the Potomac watershed. Although the storm was not as severe in the range of *Ptilimnium nodosum,* observations at severely impacted streams suggest habitat loss would vary depending on the nature of the stream channel (Bartgis, pers. obs.). During severe, but not huge, storms, entrenched segments get scoured more severely than segments with well-developed floodplains. This may be why the largest stands of *Ptilimnium* are often associated with the floodplain areas; these stands have had longer periods to grow. In huge storms such as Hurricane Juan, scouring is severe everywhere, although sheltered bedrock outcrops in the entrenched areas may be less severely affected.

Because of the normal dynamics of stand loss and creation, and the shifting mosaic of habitat along the creek, we believe protected stream segments should include a mosaic of small to large stands over a variety of stream morphologies. Furthermore, protected segments must contain areas of appropriate habitat that do not currently contain *Ptilimnium.* This will increase the probability that new stands can be created as they are naturally lost.

Identifying potential sources of sedimentation and other pollutants has been a major concern. If disturbed, steep slopes near the stream and along tributaries could introduce substantial sediment to the stream system. Transplant studies of *Ptilimnium* have shown that mortality was substantially greater near the National Freeway than at control sites on the creek (Maddox and Bartgis 1992). The cause of the higher mortality is not known, although chloride levels are substantially higher near the freeway than elsewhere.

Based upon what had been learned about *Ptilimnium nodosum* and Sideling Hill Creek, we established certain criteria to help guide habitat conservation activities on the stream. These are: (1) Protection efforts for *Ptilimnium nodosum* should emphasize stream segments containing a variety of stand sizes, a mosaic of potential habitat areas, varied stream morphology, and uplands which can be protected to prevent sedimentation. Protecting such habitat mosaics increases the chance that *Ptilimnium* stands will be able to "move" in response to shifting stream morphology. (2) Stream segments upstream from concentrations of *Ptilimnium* should be considered for preservation in order to maintain water quality and conserve other biodiversity features. (3) Conservation programs should not overlook activities in the watershed away from the stream itself that may impact water quality and flow characteristics. For example, reduced stream flow would subject *Ptilimnium* to extended periods of dryness, of which the species is intolerant (Maddox and Bartgis 1992).

The effective protection of *Ptilimnium* requires a landscape-level approach. At Sideling Hill Creek this landscape also includes many other biodiversity features of interest. Consequently, conservation efforts for *Ptilimnium* on Sideling Hill Creek should incorporate other rare species, special community examples, and other resources such as habitat for forest-interior dwelling birds. Where possible, examples of common communities should also be included in conservation programs so that a full suite of natural communities can be maintained along the stream.

Implementing Landscape-Level Habitat Protection

Existing land-use patterns along Sideling Hill Creek are currently suited to protecting large stream segments. In Maryland, fewer than fifty privately owned tracts, averaging 25 ha, border the stream. Two large public land areas also occur along the creek, Green Ridge State Forest and Sideling Hill Wildlife Management Area. The Maryland Department of Natural Resources and The Nature Conservancy have begun to protect landscapes along the stream. It was recognized from the beginning that such a program would require a wide-range of tools, including designation and management of public lands, acquisition, cooperation with private landowners and education.

During this study period most stands of *Ptilimnium nodosum* occurred on or near lands owned by the State of Maryland (Figure 1). This area coincides with concentrations of shale barrens, mussels, and other rare species and has a diversity of land-forms. Consequently, this section of stream was selected as a focus for habitat protection efforts. The state has taken several actions directed at the conservation of *Ptilimnium nodosum* and other biodiversity resources on state lands. These include erosion prevention directed at slopes which contribute run-off (and potentially sediment) to the stream, preservation of large blocks of forest, and protection of lands which contain other rare species.

Two segments of Sideling Hill Wildlife Management Area have been designated as Natural Heritage Areas (Figure 1). This is a regulatory designation which recognizes the significance of the areas for biological conservation. The northern Natural Heritage Area (Figure 1) has been nominated as a state Wildland. If approved, the designation would offer protection similar to designation of federal lands as wilderness.

A Habitat Protection Area has been designated for the portion of Green Ridge State Forest which borders and drains into Sideling Hill Creek. Although this administrative designation carries no legal protection, Habitat Protection Areas define state lands on which management actions are to be reviewed for potential impacts on biodiversity features.

During this study a significant percentage of stands of *Ptilimnium nodosum* not on state lands were located on a 320+ ha tract near the creek's mouth. This tract also supports rare mussels, high-quality forest communities, and shale barrens. In 1991 the Maryland Department of Natural Resources, with the help of The Nature Conservancy, acquired this tract using monies from the Heritage Conservation Fund (Figure 1). A youth group and the National Guard had existing use rights to the property, so the acquisition effort included a series of leases and management agreements to define management and use of the tract. The highlight of this effort is the establishment of a primary protection area in

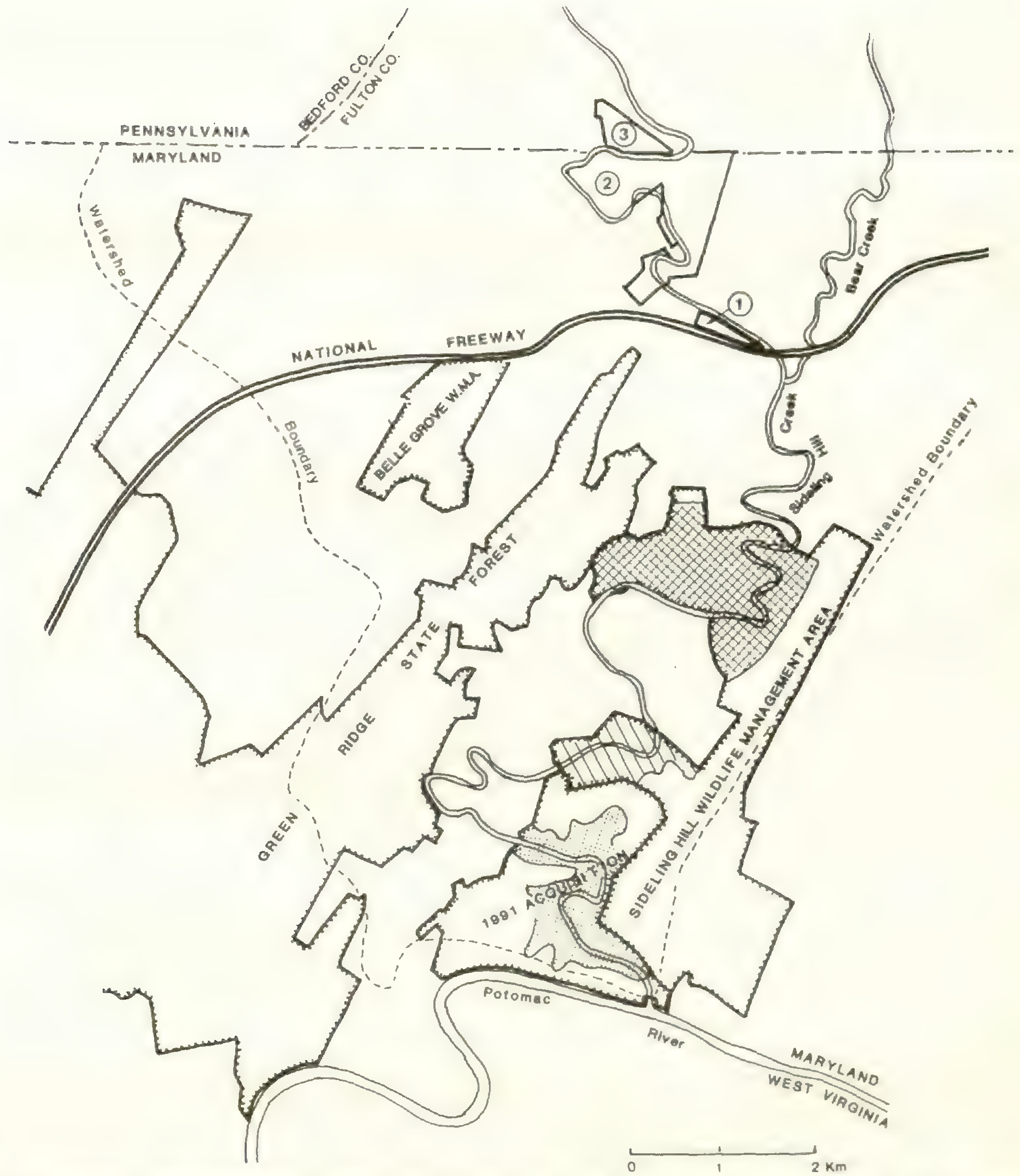
PENNSYLVANIA
MARYLAND
BEDFORD CO.
FULTON CO.
③
②
①
Watershed Boundary
NATIONAL FREEWAY
BELLE GROVE W.M.A.
Bear Creek
Sideling Hill Creek
Watershed Boundary
GREEN RIDGE STATE FOREST
SIDELING HILL WILDLIFE MANAGEMENT AREA
1991 ACQUISITION
Potomac River
MARYLAND
WEST VIRGINIA
0
1
2 Km

FIG. 1. Sideling Hill Creek watershed in Maryland and lands associated with the landscape conservation program. The hatched areas are designated Natural Heritage Areas within Sideling Hill Wildlife Management Area. The cross-hatched area is also the proposed Sideling Hill Creek Wildland. The stippled area within the 1991 acquisition tract is the primary protection area. The numbered areas represent: (1) the State Highway Administration Natural Area; (2) private lands of the Maryland Cooperative Natural Areas Registry; and (3) The Nature Conservancy/Western Pennsylvania Conservancy acquisition in Pennsylvania.

which protection of the stream, adjacent slopes, special communities, and endangered species is the primary management goal (Figure 1).

Most private landowners along this critical section of creek have been notified of the significance of the stream and the impacts of shoreline erosion and other activities. The Maryland Cooperative Natural Areas Registry, a voluntary land-protection program (see Hoose 1981) of The Nature Conservancy and Maryland Natural Heritage Program, have also been involved on Sideling Hill Creek. Most private stream frontage between Pennsylvania and the National Freeway has been added to the Registry, as has a Maryland State Highways Administration tract, which supports the northernmost known stand of *Ptilimnium nodosum* (Figure 1).

Pennsylvania conservationists have also shown an interest in protecting segments of Sideling Hill Creek in their state. Not only will this effort help protect species and ecosystems of concern in Pennsylvania, it will hopefully help maintain stream quality downstream. The cornerstone of the effort was the acquisition of land along the stream at the PA-MD border by The Nature Conservancy and Western Pennsylvania Conservancy (Figure 1).

Conclusions

Although existing land-use patterns along Sideling Hill Creek have been conducive to a comprehensive program for landscape-level conservation, many issues remain. Progress to date has been on establishing a conservation corridor along the stream itself. The opening of the National Freeway across Sideling Hill Creek in 1988 may lead to land-use changes throughout the watershed, including residential and commercial development. It will be necessary to work with local landowners and planners to minimize impacts of changes in land-use on water quality and hydrologic characteristics of the stream.

Currently, no activity in the Sideling Hill Creek watershed is known to be significantly impacting water quality or flow characteristics, but potential impacts need to be identified and anticipated. For example, an analysis of riparian habitat dynamics along the St. John's River in Maine indicates that timbering practices upstream in the watershed have increased peak river stage levels concommitant with a decline in the endangered plant *Pedicularis furbishiiae* (Menges 1990).

Site-specific stewardship problems also need to be identified and addressed. For example, a significant amount of the sediment which enters the stream is from dirt roads which border or ford Sideling Hill Creek (Maddox and Bartgis unpublished data).

To create an effective program, though, the most difficult problems will be dealing with the complexities of protecting a riparian system at the landscape level. There is a possibility that landowners, managers, and planners will not recognize the potential implications of their actions on the creek beyond some distance within which the relationship to the creek is obvious. The viability and security of *Ptilimnium nodosum,* other endangered species, and the natural communities must be continuously monitored. The interest of all participants involved in maintaining this landscape, including private landowners, public land managers, and public land users, must be continuously cultivated.

Acknowledgements

Our research was funded by the Chesapeake Bay and Endangered Species Fund, the Maryland State Highways Administration, and the US Fish and Wildlife Service. Habitat protection efforts have been conducted by The Nature Conservancy, the Western Pennsylvania Conservancy, Maryland Program Open Space, and the Maryland Natural Heritage Program. Our research activities were assisted in the field by Ashton Berdine, Laurie MacIvor, and Johanna Thomas. Josephine Thoms prepared the figure. D. Daniel Boone, Edward Thompson, and Charles Bier were instrumental in developing a broad view of the biodiversity resources of Sideling Hill Creek.

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Bartonia No. 57, Supplement: 50–57, 1993

Extinct, Extant, Extirpated, or Historical? or In Defense of Historical Species

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"Down the bluff I went where the water had cut its banks into the limestone and here and there in the crevices of dry limestone was *Bouteloua curtipendula* growing just as Porter said it was a hundred years ago. Porter is dead and long gone and virtually forgotten but the small grass is thrifty and annually casts its seeds despite the passing of its discoverer . . . the constancy of the limestone and the Delaware River and the curious grass continues despite the curious eye of the inconstant passer-by." Vincent Abraitys.

Relocating a rare species at the exact location discovered many years before by a long dead predecessor is an experience that is particularly satisfying to the field botanist. Foremost, it creates a conservation opportunity that did not previously exist. And, as Vincent Abraitys (1975) poignantly related, it is also a leveling experience for us humans, because it puts our brief existence in its proper perspective. An individual lifespan is often the measure and the extent of our experience of time. To us then, one hundred years becomes a significant chunk of time, which is why we often are amazed when we hear that someone has relocated a rare species after such a lapse of time. But considering the thousands of years that many of New Jersey's plant species have been in the state, is it really all that amazing? Given this anthropocentric view of time, is it any wonder that we tend to underestimate the tenacity that many rare and endangered plant species exhibit in persisting in a human-altered landscape?

CLASSIFICATION OF RARE SPECIES

Unfortunately, this human-skewed bias of time has become manifested in our approach to the classification of rare and endangered plant species. Nowhere is this more evident then in the process of how species (or populations) are determined to be extant. Often time is used as the single criterion in separating the extant species from the extinct, the extirpated, or the historical. When time is used as the sole measure of the "extantness" of a plant species, the distinctions and value of these different ranks of classification become obscured, and even redundant.

A ranking system based entirely on time is certainly attractive in its convenience. For example, if an extant plant is defined as having been documented within the last five years, it is very easy to sort out the extant from the non-extant. But is this a realistic representation? Do plant species cease to exist after the fifth year passes? Or even the fiftieth?

Another approach is to simplify the classification system by eliminating ranks. After all, common sense tells us that a plant species is either extant or it isn't. Set in this context, the rank of historical becomes a logical impossibility—obviously a plant species can't both exist and not exist at the same time. But the problem with this either/or approach is that it does not take into consideration that our ability to document the simple reality of a plant's existence is limited and sometimes inconclusive. There is no room for uncertainties in a classification system based entirely on yes or no. A system that forces all species to be pigeonholed as either extant or not results in arbitrary decisions being made when supporting data is lacking or ambiguous.

To those insisting on absolutes, the idea of historical species may be viewed as a conservation contrivance—a fudge factor used in the absence of quantitative data. It would be nice to be able to devise a ranking system based strictly on quantifiable data, but the numbers, diversity, and biological complexities of the species under consideration, preclude reducing data to a few, easily measured common denominators.

The dilemma then is in achieving congruency between our limited ability to document a plant species' existence with its absolute reality. The most unfortunate and uncomfortable aspect of this dilemma is that what we are trying to prove is ultimately knowable, but our resources to do so are finite. The reality of conservation biology is that time, staff, and financial resources are all in short supply dictating that concessions be made. The conservation rank of historical is one of these necessary concessions.

The concept of historical species allows us to tackle head-on the limitations of our methods and abilities to document a plant's existence. It acknowledges the uncertainties and gaps in our knowledge without sidestepping common sense by employing convenient short cuts that only work on paper or are valid only in theory. The need for an historical rank becomes apparent when we try to sort out the extant species from the less than extant—not as lists on paper, but as living organisms, each presenting a unique set of problems.

EXTANT, EXTINCT OR EXTIRPATED? I consider a plant to be extant when its presence on the landscape is, or can be, verified by direct experience. That is, when someone can go out, see it, touch it, collect it, photograph it, or by any other method document its existence. The fundamental problem in documenting a plant species extant is that since it is always subject to destruction by natural or human caused events, its existence must be continuously re-verified. As a result, all practical methods used to document species extant are valid only for the specific points in time in which they were made. Mackenzie's 1917 collection of *Lechea tenuifolia*[1] documents only that it was extant at the time he collected it; to determine whether it is extant today requires a field survey.

Because of the uncertainty of a plant's continued existence and the limitation of our documentation, it is sometimes much easier to determine that a plant no longer exists, then to prove that it does. Once destroyed, there is obviously no need to re-verify a plant's nonexistence. When a plant species is determined to no longer exist, it is classified as either extinct or extirpated. In conservation biology these terms are used to distinguish species that no longer exist in a living form anywhere on the planet (extinct) from those that are only absent from specific portions of their geographical ranges (extirpated).

Currently, the only New Jersey species conclusively meeting the definition of extinct are an indeterminable number of species known only from fossil or pollen records. *Micranthemum micranthemoides* may be extinct, since no extant populations are currently documented throughout its geographical range. However, persuasive evidence of its extinction has yet to be presented (US Fish & Wildlife Service, 1990). *Narthecium americanum* and *Rhynchospora knieskernii* are potential candidates for extinction since both are currently documented extant only from a small area of New Jersey's Pine Barrens. Several populations of these species occur on protected state-owned land so their continued survival is at present reasonably secure.

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[1] Nomenclature follows Kartesz & Kartesz (1980).

Applied to levels or ranks of New Jersey plant endangerment, extirpated is used to identify species which are believed to no longer occur anywhere in the state as a native wild plant; either because known populations have been confirmed destroyed or because their existence on the landscape is beyond practical verification.

DOCUMENTING EXTIRPATION. Documenting a species as extirpated can be a straightforward procedure as it was for *Ledum groenlandicum. Ledum* is a conspicuous shrub with showy flowers that is restricted to quaking bogs or peatlands throughout glaciated portions of North America. In New Jersey, it was documented from a single bog near Mount Hope, Morris County, which was destroyed in the late 1970's by the construction of a shopping mall (Snyder 1987). True quaking bogs are extremely rare natural communities in New Jersey and all known occurrences have been surveyed without success for *Ledum.* Like the bogs themselves, *Ledum* was probably of relictual occurrence in the state and the probability of new colonizations from out of state populations seems remote. For species like *Ledum,* which occur in well-defined or geographically restricted habitats, field work can be a directed, methodical elimination of possibilities and a determination of extirpation can be made with a reasonable degree of confidence.

But if a species occurs in a widespread or common habitat, this level of confidence is not always possible. *Cacalia muhlenbergii* is a good example. It was collected a few times between 1862 and 1869 from a single location along the Delaware River near Camden at a site which has been destroyed by urban and industrial sprawl. The only habitat information contained on specimen labels is "banks of the Delaware River." By extrapolating general habitat information from regional manuals and from what is known of the New Jersey location, potential habitat can be interpreted as rich woods and thickets along rivers and streams in the Coastal Plain. This eliminates highly urbanized areas, most of the Pine Barrens, and probably all of the coastal strip, but it still leaves thousands of acres of potential habitat to search. If the objective is to be able to state with absolute certainty whether or not *Cacalia muhlenbergii* still exists in New Jersey, it would be necessary to search every last square yard of potential habitat. The amount of effort necessary to accomplish this is both prohibitive and unrealistic as a conservation goal. As far as the preservation of *Cacalia muhlenbergii* in New Jersey is concerned, there is not much more that can be done—since recent searches of appropriate areas along the Delaware River near Camden have not located suitable habitat and more than 100 years of field work in the general area have not been successful in rediscovering the species.

For some species, even less information is available. *Arnica acaulis* is known from a single 1852 collection labeled, "Atlantic County." *Chasmanthium latifolium* is known from a single undated, but certainly pre-1863 (the year of its collector's death) specimen, labeled, "NJ" General rangewide habitat information for these species is not very helpful in directing field work. Using Gleason's (1952) habitat characterization for *Arnica* as "sandy pine woodlands, often in damp soil" nets you all of the Coastal Plain, while Fernald's (1950) "shaded slopes and wooded thickets" is virtually useless in narrowing the search for *Chasmanthium.* In situations like these, biogeographical information may be of some use, such as checking their distribution in adjacent states, but for these particular species it is of little value. The remaining option is to conduct random searches in seemly appropriate habitat. A formidable, and again, unrealistic task, when the amount of ground to cover is considered. If, as in these examples, the only means of relocating a species is by random or serendipitous field searches, then its practical conservation value has been extinguished and a rank of extirpated is appropriate.

Extirpated species have no tangible significance in land conservation or regulatory programs; you can't preserve what doesn't exist. The ranking of extirpated should therefore be reserved only for those species for which there is no realistic expectation of their being found. Our flora is of course dynamic, and species presumed extirpated are sometimes rediscovered. Plants continue to migrate and species are reestablished. Overlooked populations are occasionally discovered. But these events are rare and unpredictable, and remain beyond the bounds of practical conservation efforts.

VALUE OF 'HISTORICAL' CATEGORY

Because determining whether a plant species is extant or extirpated can be both a lengthy and difficult process, many species are caught somewhere midstream—their presence on the landscape is neither currently verifiable, nor have they been determined extirpated. It is this circumstance that defines historical species.

The primary reason that species are classified as historical is because not all their documented or potential localities have been adequately surveyed. An assumption is made that with additional field work, historically ranked species can be relocated. This assumption makes historical species an active conservation priority, and the subject of intensive field work to identify which populations still exist.

In the past 30 years of field work in the state, a number of species that were once presumed beyond relocation have been found at the same locations documented many years before. For example, in 1959 Vincent Abraitys rediscovered *Dicentra canadensis* at a site discovered by Mackenzie in 1922 (Snyder 1984). In 1956, Fables (1960–61) listed it as one of his "lost plants," stating in his preface, "possibly someone knows a station for one or more of [these species], but this information was unknown to the compiler." By this statement it is apparent to me that Fables was unaware of the explicit directions to the site contained on Mackenzie's specimens, or if he was aware of the directions, he never used them to relocate *Dicentra canadensis.*

Asimina triloba is another example of plant that was never truely lost. Britton (1889) lists three sites in Atlantic, Hunterdon, and Mercer counties. Stone (1911) quotes the same three localities adding, "I have been unable to find any specimens from the State or to see the tree growing." In 1915, Mackenzie relocated *Asimina* on the same Hunterdon County island cited by Britton. By 1956, *Asimina* was once again a "lost plant" (Fables 1960–61). In 1965 Abraitys found the Hunterdon site, and in 1976, he relocated what is probably the Crosswicks Creek locality cited in Britton's catalog (Snyder 1984).

Under today's ranking criteria, neither *Dicentra canadensis* nor *Asimina triloba* would have been classified as extirpated since obviously neither were beyond relocation. For each example, exact locations had been documented, both in the literature and on herbarium specimens, but only Abraitys seems to have made use of the information in recent years.

RELOCATING HISTORICAL COLLECTION SITES. No matter how old the literature reference or the herbarium specimen, it is often the best source of information for relocating historical species. For example, in 1990, I found Svenson's 1931 Passaic County location for *Pycnanthemum torrei.* I relocated in 1989 Chrysler's Watchung Mountain site for *Cercis canadensis* within 30 minutes of examining his 1935 specimen at CHRB. In 1988, I relocated New Jersey's only locality for *Schizachne purpurascens* at Branchville, Sussex County where it was last collected in 1935 (Snyder 1989). Prior to my 1986 collection, the last collection of *Geum vernum* was made in 1936 at a site along the Rancocas River (Snyder 1989). In 1910, Mackenzie noted that *Vicia caroliniana* was locally frequent on Sparta Mountain; it was still frequent there in 1985 (Snyder 1986). There is nothing extraordinary or exceptional about these relocations. All were found by using the location data contained on specimen labels. Since in each case I found the species on my first field visit, I suspect that I was probably the first botanist in recent time to seriously search them out. These species are clearly examples of historical, not extirpated, species. To have ranked them as extirpated, would have been grossly premature. Certainly extreme lapses of time justify reasonable doubt as to whether a species is still extant, but it is not persuasive evidence of extirpation.

Rediscovering historical species often is not as easy as were preceding examples. I spent many years searching documented locations for historically ranked species like *Onosmodium virginianum, Polygonum glaucum, Pyrola chlorantha,* and *Solidago rigida* before rediscovering them. Each of these species had been documented from numerous locations. For example, *Pyrola chlorantha* has been collected from more than 30 different locations, essentially statewide. Since there is no easy way of telling which historical population may be extant, all sites may have to be searched before the species is relocated. I have been searching for *Cacalia atriplicifolia*[2] for more than a decade and, at this point, have only adequately searched 12 of the 32 documented locations.

Not all historical plants are conspicuous like *Cacalia atriplicifolia,* a three to six foot high composite. If you don't find *Cacalia* at a particular locality, you can be reasonably sure it is no longer present. But with a small, inconspicuous species like *Micranthemum micranthemoides,* you never can be quite certain that you haven't overlooked it. The search for *Micranthemum* is further complicated because not only does it look like other species occupying the same habitat, but its habitat of muddy tidal flats is both difficult and unpleasant to search. Not only do you have to worry about sinking into tidal ooze, but you need to time your field work to correspond to a low or outgoing tide. I suspect this is in large part why no one has yet given up on relocating an extant population of *Micranthemum.*

For some historical species not only is the habitat difficult and unpleasant to search, but it can be nearly inaccessible, even outright dangerous. *Dicentra eximia* and *Asplenium pinnatifidum* come to mind. *Dicentra* was discovered in 1933 on ledges and cliffs high up on the face of Mount Tammany at the Delaware Water Gap (Edwards 1933). With the aid of a spotting scope (and while standing firmly on solid ground at the foot of the mountain) Vincent Abraitys confirmed a few plants extant in 1963 (Snyder 1984). It is not known to have been observed there since and the speculation is that the construction of Interstate 80 may have impacted its habitat. My few feeble attempts at its relocation have been both inconclusive and harrowing. The species is still extant on the Pennsylvania side of the Water Gap, and I'm confident that with additional searching, it will be relocated at its New Jersey location. As for *Asplenium pinnatifidum,* Rick Radis braved the heights and venomous snakes when he recently relocated Edward's 1939 station for it on the vertical cliff face of the Kittatinny Mountain in Sussex County.

Occasionally, a species may remain classified as historical because a documented occurrence is on private property to which the landowner refuses access. The only currently known population for *Scleria verticillata* was not re-verified extant until 1977 when Vincent Abraitys secured permission from the landowners to search for it. The current land owners are trying to sell the property and have flatly stated that they don't want any botanists snooping around. *Scleria verticillata* has been documented at this locality for more than 100 years, and as long as its habitat remains undisturbed, I expect it to be there for many more, whether or not any botanist gets to see it. Another example is *Linum intercursum.* This species had eluded me for more than a decade. The most recent collection for the state was a 1939 collection by Long from Burlington County. This site had always been my first choice to search, since I had a pretty good hunch exactly where the plant had been collected. Unfortunately, it is also the most widely known location for the highly prized *Platanthera integra,* and the resulting abuses by orchid hunters as well as nonbotanical vandals, have forced the landowner to restrict access. In August, 1990, Ted Gordon obtained permission for us to search the site, and, within a few minutes we relocated *Linum intercursum.*

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[2] In September, 1992, Charles and Mary Leck rediscovered this species in Burlington County along Crosswicks Creek, near Yardville. It was growing in an moist, open thicket on the flood plain, and not in the drier woods on the steeper slopes of the ravine as described on the majority of the herbarium specimens. In my attempts to relocate this species, I have of course confined all my searching to upland habitats. Such preconceived ideas about the habitat of historical species obviously confound our efforts to relocate them.

The rediscovery of some historical species has been impeded by their own biological peculiarities. New Jersey's only confirmed extant population of *Triphora trianthophora* had not been seen for many years until Tom Halliwell and I relocated it in 1979. We got the location from Vincent Abraitys, who had been taken to its Morris County site by J. L. Edwards, one of its discoverers. Although Abraitys was taken to the exact spot where Edwards had last seen the plant, no *Triphora* could be found. Vince spent another twenty years or so unsuccessfully trying to find *Triphora* there; Tom and I found it on our first search. *Triphora,* like many other orchid species, is notorious for its wide population fluctuations and, at times, produces no above ground vegetation.

Species like *Rhynchospora knieskernii* and *Scirpus longii,* both listed as "lost species" by Fables (1960–61), are suspected seed bankers, and apparently lie dormant in the soil for many years, until conditions again become favorable. *Rhynchospora knieskernii* had not been collected at Atsion for more than 100 years, but after the great fire of 1983, Jim Stasz located a sizable colony. After the fire, *Scirpus longii* was found there by the thousands (Schyuler and Stasz 1985), where previously it was known from only a few isolated patches.

Weather patterns also affect searching for historical species. Some, restricted to Coastal Plain pond habitats, appear only during seasons when the water levels are very low. Others can be inventoried only in years of normal or high water levels. The Bennett Bogs in Cape May County provides a remarkable number of examples. One historical species I'm currently trying to relocate there is *Rhynchospora rariflora,* which grows in sedgy turf on the exposed pond bottom. It has been collected or observed at Bennett Bogs at least once every decade since it was discovered there in 1907 (Stone 1911). The last known collection was made in 1973 by Abraitys and the last known observation was made by Gil Cavileer in the early 1980's (Gil's population which was one of three documented for Bennett Bogs may have been destroyed by some recent adverse impacts to the habitat). The 1990's may very well be the decade of *Rhynchospora rariflora's* rediscovery, but so far it's been a washout; 1990 being the second consecutive year of exceptionally high water levels.

There is something extremely unsettling in watching the population of Coastal Plain pond species decline from hundreds of plants in one year, to few or none in succeeding years. But we must always be on guard not to allow our anthropocentric view of time to undermine the conservation of species that display cyclical adaptations to their environment by manufacturing a conservation crisis when in actuality all may be well.

SEEKING NEW SITES. Searching potential habitat can be just as challenging and rewarding as searching documented historical locations. *Carex jamesii, Carex oligocarpa, Desmodium sessilifolium, Linum sulcatum,* and *Muhlenbergia capillaris* are all examples of historical species recently relocated as a result of searching potential habitat (Snyder 1986, 1989).

One of the greatest benefits obtained from the systematic field searching of historical locations, is the assimilation of habitat data into a search image which allows you to more narrowly focus future searching or to predict new locations. I rediscovered *Muhlenbergia capillaris* this way. Once I had developed a feel for its traprock glade habitat at historical collection sites on the Watchung Mountains, I began systematically searching similar sites in the general area. In late September of 1985 I found a small population about three miles east of where Miller had last collected it in 1918. Within two weeks, Tom Breden and I found a second population in Passaic County, approximately 20 miles northeast of the first. Its discovery there was purely predictive based on previous knowledge of the presence of suitable habitat. In September of 1987, the same search image was used to relocate Mackenzie's 1904 Sussex County location. I had searched this location once before, but as I later realized, I had focused on the wrong habitat.

My rediscovery of *Lechea tenuifolia* in the fall of 1990 succinctly underscores the necessity of confirming through first hand field work that an historically documented location has truly been destroyed and that no unsearched potential habitat remains in the immediate vicinity. The only vouchered collections for this species in New Jersey had been Mackenzie's 1916 and 1917 specimens collected at Ringwood Junction, Passaic County.

Ringwood Junction, and much surrounding acreage, was destroyed in the late 1920's by the creation of Wanaque Reservoir. From the detailed directions contained in Mackenzie's collecting journal, it is evident that the original collection locality is now submerged under millions of gallons of water. But neither Mackenzie's specimens labeled "dry fields" and "dry sunny banks," nor Fernald's (1950) general rangewide habitat of, "dry sandy or rocky open woods and slopes," describes a plant of exacting habitat requirements. Aerial photoquads indicated that plenty of this habitat still existed near the original locality. I further reasoned that because Mackenzie described the species as being "local" and because so much seemingly suitable habitat still existed, the probability of finding it was good. On my first field visit to the area, at my first stop at what seemed like a good place for *Lechea tenuifolia,* I found it. Fifty-eight plants were growing on a dry rock ledge in open woods, approximately 1.5 miles south of what once had been Ringwood Junction. Like the *Bouteloua curtipendula* that Abraitys found at Porter's last century locality, *Lechea tenuifolia* is still alive and well in New Jersey.

CONCLUSIONS

It is experiences like these that have shaped and continuously reinforce my thinking on the necessity of having a conservation rank of historical. The search for historical species doesn't always end successfully; species are, and will continue to be, extirpated from New Jersey. But let's not be premature in ranking a species extirpated before anyone has bothered to look for it, or because some arbitrary statute of limitations has expired. If the habitat for a plant still exists there is a more than even chance that the historically documented plant species is still present, regardless of how much time has passed.

I am certainly not advocating that we spend conservation dollars on maybes, but only that we recognize the conservation potential of species that have not been proved beyond a reasonable doubt to be extirpated. Historically ranked species are among New Jersey's rarest plants and we should make it a priority to resolve their status as promptly as possible. As the destruction of our natural landscape escalates, the resulting loss and degradation of habitats and ecosystems remind us that we no longer have all the time in the world in which to act. Several of our rare species may not survive the next ten years, let alone the next 100 years.

ACKNOWLEDGMENTS

I thank the following for their help in the preparation of this paper: Maude Backes, Tom Breden, Gil Cavileer, Ted Gordon, John Konkle, Tom Halliwell, Larry Morse, Rick Radis, Joanne Ruscio, and the curators of CHRB, NY, and PH. I want to especially thank all those who have contributed to, and continuously work to refine The Nature Conservancy's Global Ranking System. The final measure of a system of classification is not whether it is absolutely perfect, but whether it meets the objective of practical biological conservation.

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Bartonia No. 57, Supplement: 58–60, 1993

County Natural Areas Inventory

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The County Natural Areas Inventory (CNAI) program is an effort to locate, evaluate and map the locations of rare, threatened, and endangered species, exemplary natural communities, and other areas of significant local interest. This information can be useful for guiding development away from the most environmentally sensitive areas through land-use planning and zoning, and for proactive conservation efforts such as acquiring land for nature preserves.

Much of the information on species of special concern in PA is available in the museums and libraries of the Commonwealth and in the files of the Pennsylvania Natural Diversity Inventory (PNDI). Since its inception in 1982, the PNDI data base has become increasingly utilized by the public and private sectors for information about locations of species of special concern when development or other land use change is proposed. This increased use has pointed to the need for "upfront" information to make the process of evaluating development proposals more efficient and less costly for all parties concerned. The CNAI has grown out of this need for information on the locations of rare, threatened, and endangered species and unique natural habitats early in the decision-making process and in a format that is useful to planners and developers. The inventory provides government officials and public and private development agencies with one more tool with which to make decisions for siting open space and development, and targeting land to preserve in its natural state. Through field survey, the inventory provides biologists with more information on biotic diversity in the county and the Commonwealth.

To date, county inventories in eastern Pennsylvania have been funded through a variety of sources. Most prominent among these has been the Department of Community Affairs via the Recreational Improvement and Rehabilitation Act grant program. Additional funds have been obtained through Community Development Block Grants, the Eastern Pennsylvania Chapter of The Nature Conservancy, county government, legislative appropriation, and local nonprofit conservation groups.

METHODS

Methodologies for county natural areas inventories began with surveys in Illinois (White 1978) and Indiana (Anonymous 1985). The primary focus of the CNAI is to locate and assess exemplary natural communities, areas that are relatively undisturbed by humans or have recovered sufficiently from prior disturbances to closely resemble their natural state, and are of a size to maintain their integrity into the foreseeable future. Examples of undisturbed natural communities are old-growth forest, glacial bogs dominated by *Sphagnum* spp., leatherleaf (*Chamaedaphne calyculata*) and sedges (*Carex* spp.) on a floating peat mat, or eastern serpentine barrens with their mosaic of woodland, savannah, and prairie.

Plants and animals of special concern in Pennsylvania are included in the inventory survey using the PNDI database as a guide for relocating old sites and for locating new ones. When new sites are located, population status is evaluated to permit ranking the site against other known locations for the species.

Areas of local significance are also included in the inventory. These are areas that have been disturbed and contain no known species of special concern but do have other attributes that make them potentially valuable for preservation. For example, relatively large tracts of successional woodland are valuable for wildlife and low-impact recreation. These "sites of local significance" become increasingly important in highly urbanized landscapes.

The first step in the county inventory process is to review the PNDI data base file for the county. The file is a compilation of historical and extant locations for the elements (natural communities and species of special concern). Given this information, we then review aerial photography of the county stereoscopically. Usually the county planning office is the source of the photos, and it typically consists of 9 in. × 9 in., black-and-white prints ranging from 2 to 8 years old. We have also been able to use large-scale, color-infrared photos in Pike and southern Wayne counties courtesy of the US Army Corps of Engineers. Natural communities often have distinctive "signatures" (pattern, tone, texture, reflectance, etc.) on air photos that make them readily identifiable. Species of special concern are often associated with particular habitat types that can be identified from the photos. Known locations of natural communities and species of special concern are identified and these same photo patterns are then looked for in other areas of the county. Soil and geologic survey maps are also utilized to help identify potential locations for elements. When a possible area is located, it is marked on a USGS topographic map as a Potential Natural Area (PNA) and rated for the likelihood of finding elements during a field survey.

An aerial survey may be done at any stage during the inventory but the dormant season seems to provide the most information on previous land use and forest species composition. If the aerial photography is relatively old and the county is experiencing rapid growth, the landscape may have changed dramatically since the time of photography. Areas that appear to have potential on the photos may no longer exist and this can be most easily and quickly verified from the air. A few hours in the air early in the inventory can save a great deal of time on the ground. When the photography is recent, an aerial survey toward the end of the field season can aid in assessing which of the remaining sites to be surveyed actually hold much potential.

Results and Discussion

New information on species and natural communities has differed with each county studied. In those counties that have been studied for a long time or where much of the natural habitat has been altered, little new information has been forthcoming. In counties that may have been little studied, or where vegetation is still intact, much new information has been uncovered. For example, in Pike and Wayne counties the number of elements was doubled (Table 1). This may also be due, in part, to the quality of the photography available. Recent, large-scale, color-infrared photography (used in Pike and southern Wayne counties) provided much more information about the landscape, species composition, and subtle changes in soil wetness, etc., than did the black-and-white photography available for most counties.

The addition of information on animal species of concern has been far more difficult to generate in inventories designed for one field season. However, the CNAI process does produce information for potential new occurrences for those species that have specific habitat or food requirements. These sites can be checked in the future. Although any new information may be too late for inclusion in the original CNAI report, addendums are planned for each county as new information is acquired.

TABLE 1. Pike and Wayne County element occurrences added to the Pennsylvania Natural Diversity Inventory data base as the result of county natural areas inventories in those counties.

Extant Element Occurrences	Pike	Wayne
Total pre-1989	72	98
Additions		
Natural Communities	44	24
Plants	38	49
Animals	5	0
Total Additions	87	73

To date, in eastern PA,[1] six inventories have been completed and five more are in various stages of preparation. The reports we produce consist of USGS topographic maps, each accompanied by a table and text. The maps show extant natural communities, species of special concern, and locally significant site locations. The table lists the rarity of the element, its protection status, quality of the site, and the date last observed. The text describes each site, its importance, and possible threats or recommendations for protection. Species of special concern are identified by map code only because of the potential for over-collection or malicious destruction.

Because many of the sites are wetlands, we usually map the watershed boundary as well as the site itself. The watershed often provides an ideal buffer zone around the element; if the entire watershed can be protected the elements have a reasonable chance for long-term survival. Even if the entire watershed cannot be protected, planners can take steps to ensure that only compatible activities are allowed to take place to avoid serious impacts to the elements. Given the inventory information, developers can avoid areas where they are likely to encounter delays in approval for their plans, if not denial. Developers can also improve their chances for approval of projects by incorporating protection of rare elements located in the watershed.

In some cases, county and township governments will be able to use information derived from the CNAI proactively to site parks and nature preserves. The information will also be useful for local and national conservancies who need information on the priority protection sites within their purview. Since the inventory is public, there is also potential for increasing the awareness of local citizens to the importance and uniqueness of the land around them.

County inventories generate more information on the elements of special concern that groups like The Nature Conservancy are attempting to protect. New information on locations will aid researchers in determining the true rarity and site requirements of some species. Location information will also help researchers who may wish to study the habitat requirements of certain species.

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[1] The Western Pennsylvania Conservancy is conducting inventories in western counties.

Bartonia No. 57, Supplement: 61–74, 1993

The Serpentine Barrens of Temperate Eastern North America: Critical Issues in the Management of Rare Species and Communities

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Startlingly out of place in a forested and farmed landscape, a few patches of native prairie and savanna in southeastern Pennsylvania and northcentral Maryland attracted the curiosity of early naturalists. They named them serpentine barrens. Further exploration of the continent revealed that the native eastern grasslands resemble misplaced bits of the American West. The largest and best remaining examples now lie only a few miles from major metropolitan centers but few outside a handful of botanists, ecologists and neighboring residents know of their existence.

Serpentine barrens are best known to botanists as hotspots for disjunct and endemic plant species. These exceptional ecosystems are ranked high in priority for biodiversity conservation because they are rich in rare species of both plants and animals, including several that are globally rare and in danger of extinction. The barrens rate high in importance also because they comprise one of the rarest and most unusual sets of natural communities in the eastern North American temperate forest region.

Effective biodiversity conservation requires a thorough understanding of ecosystems, communities, and key species such as those in danger of extinction. Despite sporadic attention to serpentine vegetation by scientists, our understanding of its unusual properties remains far from complete. Nonetheless, we have a set of working hypotheses about how serpentine barrens communities work, how they are affected by human activity, and what needs to be done to insure their continued well being. This presentation is a summary of those hypotheses, including a brief review of the natural history of the serpentine barrens of temperate eastern North America.

SERPENTINE BARRENS CHARACTERISTICS

GEOLOGY. Farmers attempting to cultivate areas of serpentine vegetation called the land barren on learning that the thin soils were unproductive of crops and pasturage. *Serpentine* is the name of the rock type underlying the barrens.

The origin of the name serpentine is commonly attributed to the long, sometimes wiggly veins of minerals seen in some serpentine rocks. An alternative etymology points to ancient Italy. In northern and northwestern Italy lie many outcrops, similar to those of Pennsylvania and Maryland, of the mottled greenish bedrock. Around outcrops of the rock, the story goes, lives a mottled greenish snake. The match in coloration is not surprising, given the propensity for sharp-eyed birds of prey to eat snakes that do not blend in well with the colors of their surroundings. A cryptically colored snake basking on a rock is nearly invisible until it suddenly slithers away at the approach of a predator or a human observer. People assumed the snake and the rock were two different phases of the same mottled greenish substance. Since the animate phase was a serpent, they named the inanimate phase of this apparently mystical rock serpentine.

Serpentine was highly valued as a building stone in the nineteenth and early twentieth centuries in and around Philadelphia and Baltimore because of its striking light green color. Old serpentine buildings—typically churches, banks, or farm houses—still stand here and there throughout the region. Noteworthy examples of buildings made mostly of serpentine include College Hall and Logan Hall at the University of Pennsylvania, Philadelphia, and the coincidentally named Green Library at West Chester University, West Chester, PA.

Geologists call the rock serpentinite and the most abundant constituent minerals, serpentines. Serpentine minerals are hydrated magnesium silicates, mainly chrysotile (the most common form of asbestos) and lizardite. Serpentinites include variable quantities of other minerals, commonly including olivine, magnetite, chromite, talc and iron oxides (Pearre and Heyl 1960).

Serpentine minerals are formed beneath the ocean floor at fracture zones—areas riddled with giant cracks from stresses created by the movement of oceanic crustal plates (Saleeby 1984). Seawater leaking into deep cracks in the ocean's foundations reacts with the minerals olivine and pyroxene, constituents of the common oceanic crustal rock peridotite. The hydration of olivine-rich igneous rock is a type of metamorphism called serpentinization. Serpentinized peridotites are termed ultramafic—the "ma" for magnesium and the "f" for *ferrum,* Latin for iron—because magnesium is the most abundant metallic constituent followed by iron.

Magnesium's abundance in serpentine minerals and this metal's strong reactivity with certain acids explains why buildings clad in serpentine stone are particularly susceptible to damage in urban centers. There, smoke and car exhaust enrich the air with carbon dioxide which combines with fog and rain to form carbonic acid. The acid reacts with the stone to form highly soluble magnesium carbonate. The problem is severe in Philadelphia: crumbling serpentine walls at the University of Pennsylvania are routinely patched with green-dyed concrete.

If serpentinization occurs in oceanic crust, it follows that most serpentine rock must remain beneath the bottom of the ocean or disappear into the earth's interior in deep ocean trenches where the heavier ocean floor dives (subducts) beneath lighter continental crust. However, in a process that is still debated among geologists, slivers of serpentinite "pop up," most likely between continents moving toward each other just before they collide (Saleeby 1984). Serpentinite is far less dense than other oceanic rock and less dense than many continental rock types because serpentinization adds oxygen and hydrogen to the mineral structure. Serpentinite formations are buoyant relative to other rocks and float upward during the ponderously slow but violent process of continental collision. They are further boosted by the uplift of mountains which occurs along the sutures between colliding continents. The upward thrust of serpentinite coupled with the rapid surface erosion associated with mountain ranges eventually bring some serpentine rock to the surface.

Pieces of oceanic crust perched on the continents are called ophiolites—a word coined from the Greek words for snake and rock. Serpentinite's low density and tendency to float upward through other kinds of rock may be what drives the movement of ophiolites to the continental surface (Saleeby 1984). Ophiolite emplacement has been a relatively rare event in the earth's history. A true-to-scale world map of continental serpentine rock outcrops looks blank except for coastlines, at first glance. Only on close inspection does one notice widely scattered wispy streaks and specks. Every continent has a few outcrops, but nowhere does serpentinite occupy more than a fraction of one percent of any continent's surface. For example, in North America there are four extremely sparse clusters of serpentinite outcrops: Georgia to Newfoundland, Quebec to Manitoba, Guatemala to Cuba, and central California to Alaska (Irwin and Coleman 1972).

VEGETATION. Only a tiny fraction of the area of even these small outcrops bears a distinctive vegetation. Whether the vegetation overlying serpentine rock stands out as different from the surrounding plant cover depends on the mineral content of the serpentinite and on regional peculiarities of soil formation, present climate and climate history. The most extensive serpentine barrens in North America are those of California and Oregon. In temperate eastern North America, serpentine barrens range from Georgia to New York with more than 90% of the acreage lying in Pennsylvania and Maryland.

One of the first written accounts of serpentine vegetation in Pennsylvania was by John Bartram, in a letter dated 6 December 1745 to the Dutch naturalist John Frederic Gronovius: "The Loadstone [magnetite] lieth in a vein of a particular kind of stone that runs near east and west for sixty or seventy miles or more, appearing even with, or a little higher than its surface, at three, five, eight, or ten miles distance, and from ten to twenty yards broad, generally mixed with some veins of cotton [asbestos]. The earth of each side is very black, and produceth a very odd, pretty kind of Lychnis, with leaves as narrow and short as our Red Cedar, of humble growth, perennial, and so early as to flower, sometimes, while the snow is on the ground [*Minuartia michauxii* (Fern.) Farw., synonymous with *Arenaria stricta* Michx.]; also a very pretty *Alsine* [*Cerastium velutinum* Raf.?]. Hardly anything else grows here. Our people call them *Barrens*. . ." (Darlington 1849).

From the air, serpentine barrens look like islands. Most eastern serpentine barrens are surrounded by forests or farmland. The boundaries between serpentine and non-serpentine vegetation often appear as distinct as a true island's shore. Few plant species occur on both sides of these boundaries and those that do constitute an insignificant fraction of the local biomass. The vegetation boundaries in many cases mark a bedrock transition as abrupt as the boundary in the masonry of Penn's College Hall between the schist of the first story and the serpentine of the upper stories. The analogy is apt: serpentine formations in Pennsylvania and Maryland most often adjoin schist or gneiss.

The typical natural community on schist or gneiss is a mesic forest with a nearly closed canopy of deciduous forest trees. In contrast the quintessential serpentine barrens landscape is a prairie of mainly native grasses with scattered trees—usually *Pinus, Quercus,* or *Juniperus*—and exposed rock. Serpentine barrens are, quite literally, a textbook example of the influence of soil variation on vegetation structure and composition. Plant associations growing atop serpentine outcrops all over the world are cited by ecology, botany, and soil science textbooks as models of azonal vegetation, that is, vegetation resembling the norm of some other climatic zone.

Large, well developed serpentine communities are actually mosaics of different serpentine plant associations, reflecting variation in soil development, bedrock mineral content, moisture availability, successional age since the last episode of natural disturbance, and the type of disturbance (K. S. Dougherty, unpubl. ms.). The open-canopy rock exposure communities (sometimes called glades) and the grasslands are richest in disjunct, endemic and rare species. Wetlands overlying serpentine are highly minerotrophic and have a distinct flora. Several forest types also occur on serpentine including closed-canopy *Pinus rigida, Quercus stellata-Quercus marilandica* oak woods and, at one location only (in Lancaster County, PA), what appears to be a giant clone of *Populus tremuloides,* possibly a relict of periglacial climate. Serpentine forests usually have a nearly impenetrable understory of *Smilax rotundifolia* and *Smilax glauca.*

DISTRIBUTION. At the core of the eastern serpentine archipelago lie the state line barrens—a string of seven sites along 20 km of the Mason-Dixon Line in Chester and Lancaster Counties, PA, and Cecil County, MD. Six are in Pennsylvania, three extend a short distance into Maryland, and one is entirely in Maryland. Totalling approximately 850 ha, these sites comprise the largest area of serpentine vegetation in the eastern temperate zone across which serpentine-restricted plant and insect species are likely to form locally interbreeding populations. The two largest of the seven sites, Goat Hill and Nottingham Barrens, lie near the geographic center of the state line barrens. Separated by less than 2 km they encompass approximately 400 ha of serpentine vegetation, mainly savanna dominated by *Schizachyrium scoparium, Sporobolus heterolepis,* and *Pinus rigida.* Scattered glades include the only two known eastern temperate serpentine endemics: *Aster depauperatus* (Porter) Fern. (serpentine aster) and *Cerastium velutinum* Raf. (lumped with *C. arvense* L. in most floral manuals) var. *villosissimum* Pennell (long-haired barrens chickweed).

Soldiers Delight in Baltimore County, MD, a 540-ha area of serpentine vegetation 60 km southwest of the state line barrens, is the largest single eastern serpentine barrens site. Its flora is among the richest in species diversity of all the barrens but it lacks the endemics and the typical state line barrens dominants *Pinus rigida* and *Sporobolus heterolepis.*

Discounting a few very small sites (<2 ha), the remaining eastern serpentine barrens cover up to 40 ha per site and are scattered from Georgia (1 site) through North Carolina (1) and Maryland (3) to northern Chester and Delaware Counties, Pennsylvania (6), and New York (4 small sites on Staten Island). Altogether there are 23 serpentine barrens sites ≥2 ha in temperate eastern North America. A number of small areas of serpentine vegetation recorded historically has been destroyed by incompatible land use including nearly a dozen sites in the western suburbs of Philadelphia and one in northern Delaware.

All temperate eastern North American serpentine barrens occur on serpentine rock in the Piedmont physiographic province except for the one in North Carolina, which occurs on olivine and serpentinized dunite in the Blue Ridge province (Mansberg and Wentworth 1984).

DISJUNCT AND ENDEMIC SPECIES. Serpentine barrens form archipelagoes of specialized habitats for species with disjunct and endemic distributions. The characteristic plant species of the barrens can be classified in several ways: regional fidelity to serpentine, the region or habitat where they are most abundant off serpentine, and regional or global rarity. A few examples will illustrate.

One of the showiest characteristic serpentine species, *Phlox subulata,* is an example of a species restricted to serpentine locally within the counties with serpentine outcrops. Elsewhere it occurs on dry rock exposure communities including the Appalachian shale barrens. Pink Hill, a serpentine barren at Tyler Arboretum, Delaware County, PA, takes its name from the masses of *P. subulata* flowers that appear there in early spring during favorable years. Another showy species, *Lilium philadelphicum,* inhabits a variety of dry, relatively open sites, but is still considered a characteristic member of the serpentine flora.

A group with special biogeographical interest includes those species whose main range lies in the western plains. Their populations on serpentine are generally considered as relicts of a warmer and drier interval called the hypsithermal, which occurred from 7,000 to 2,500 years ago following the most recent glacial maximum (Deevey and Flint 1957). During the hypsithermal, these species may have been far more abundant across central and eastern North America. *Carex bicknellii, Bouteloua curtipendula,* and *Sporobolus heterolepis* fall into this category. *Asclepias verticillata*—an unusual milkweed with almost needle-like leaves—is also a western prairie disjunct.

Fimbristylis annua, with a mainly tropical and subtropical distribution, behaves as if it were a desert annual. Its soil seed bank suddenly germinates to form lush carpets of turf only in years when rainfall occurs abundantly and at the right time during the season. Pennsylvania's serpentine populations lie at the northernmost limit of the species' global range. *Senecio anonymus* Wood (*S. smallii* Britt. in most floral manuals) is another species reaching its northern limit in Pennsylvania's serpentine barrens. *Scleria pauciflora,* with fruits resembling miniature golf balls, inhabits soils and sands that are low in mineral nutrients. All three species occur almost exclusively on serpentine in southeastern Pennsylvania and northcentral Maryland and are classified as rare in both states.

Talinum teretifolium (fameflower) inhabits several types of rock outcrops throughout its highly fragmented range. As is typical of the Portulacaceae, its stems and leaves are succulent. The serpentine populations in Pennsylvania and Maryland define the northern limit of its range. They are separated by hundreds of kilometers from the next-nearest population on a granite outcrop in southern Virginia (W. H. Murdy, pers. comm.). How the species' tiny seeds found their way to nearly a dozen widely scattered serpentine outcrops in the northern Piedmont is a mystery that may keep biogeographers guessing for a long time. Dr. William Murdy of Emory University conjectures that they may have been lofted by windstorms or possibly by a single windstorm. Such a scenario requires a fortuitous combination of a tornado or other strong updraft raking across one or more southern rock outcrops, storm movement along a track intersecting the northern serpentines, and deposition on the serpentines. The absence of differences detectable by gel electrophoresis at 23 gene loci between serpentine and other populations of *T. teretifolium* suggests that the species' colonization of serpentine was relatively recent (Murdy and Carter 1985).

Among the rarest species living on the barrens are the two eastern temperate serpentine endemics. *Aster depauperatus,* with its distinctive summer-deciduous cauline leaves and winter-persistent basal rosette, is known from about a dozen sites in Pennsylvania and adjacent areas in Maryland. Recently, its endemic status was challenged by the discovery that it occurs at three diabase glades in north-central North Carolina (Levy and Wilbur 1990). *A. depauperatus* currently is regarded as a suspect taxonomic entity. Dr. Robin Hart has presented morphological evidence obtained from common-garden experiments that *A. depauperatus* may actually be an eastern disjunct of *A. parviceps,* a prairie species with a restricted range in Illinois, Iowa, and Missouri (Hart 1990).

The taxonomy of the other eastern temperate serpentine endemic is also in question. The species name *Cerastium velutinum* Raf. has recently been resurrected to refer to a hairy broad-leaved form of *C. arvense* L. (vars. *villosum* (Muhl.) Hollick & Britt, and *villosissimum* Pennell in floral manuals) restricted to serpentine and limestone glades (Morton 1987). The discovery that the distinctions of anatomy and habitat distribution parallel a different chromosome number makes a convincing case for the revival of the species split. *C. velutinum* may be a rare species in its own right. Its revival as a separate species is so recent that no one has yet tried assessing its global abundance.

Var. *villosissimum,* with distinctively long white hair covering leaves and stem, is often said to occur in only one place in the world—bluffs overlooking Octoraro Creek at Goat Hill, Chester County, PA, from which the type specimen was collected and described by Francis W. Pennell (1930). Herbarium specimens from at least three other Pennsylvania serpentine sites were labelled as var. *villosissimum* and a recent discovery, still unpublished, places var. *villosissimum* at a serpentine barren in Maryland. However, *Cerastium* monographer Dr. John Morton of the University of Waterloo considers var. *villosissimum* to be a taxonomically trivial form, based on several lines of experimental and observational evidence (J. K. Morton pers. comm.).

Adiantum pedatum subsp. *calderi* (serpentine maidenhair) is the only endemic shared between serpentine outcrops of both eastern and western North America. It is the most shade-tolerant of all the plants that have high regional fidelity to eastern serpentine outcrops, commonly occurring in the understory of serpentine woods. Recent biosystematic research (Paris and Windham 1988) suggests it may be better considered as a full species distinct from *A. pedatum.* The study also showed evidence that *calderi* is likely to be more closely related to maidenhair ferns of the western mountains than to the common maidenhair of eastern forests.[1]

Other globally rare and endangered species are also found on the barrens. The rarest may be *Agalinus acuta* (sandplain gerardia). It lives at one Maryland serpentine barren and fewer than a half dozen non-serpentine sites northward along the Atlantic coast. Another is *Elliottia racemosa* (Georgia plume), an ericaceous shrub or small tree whose entire range is confined to scattered sites on Georgia's coastal plain and to the Burke Mountain, GA, serpentine barren.

Euphorbia purpurea (glade spurge) is known to occur at less than 20 places globally including the Goat Hill, PA serpentine barren and a site in Virginia underlain by a gabbro formation considered to be mafic (ferro-magnesian but to a lesser degree than rock classed as ultramafic) and sharing some mineral characteristics with serpentine. *E. purpurea,* a wetland species, directs attention to the fact that not all serpentine habitats are dry uplands. Some groundwater-fed wetlands at serpentine outcrops have a distinctive flora, most often typified by *Deschampsia cespitosa* or *Sanguisorba canadensis.*

Not all rare species characteristic of serpentine barrens are plants. The unusual plant communities host numerous specialist-feeder insect species. As with plants, many of the serpentine populations of insects are disjunct from the species' main ranges. The buckmoth (*Hemileuca maia*) is one of the most conspicuous of the rare insect species with high regional fidelity to serpentine. Unlike most moths it flies during the day. It can be spotted in late October and early November by its distinctive black and white wing markings, large size, and rapid bouncing flight. Buckmoth larvae, spectacularly armed with stinging hairs, feed on the leaves of *Quercus ilicifolia.*

PHYSIOGNOMY. The salient fact of serpentine biogeography is the convergence of community physiognomy. Most serpentine communities look like dry prairies and savannas even where they are well watered and surrounded by lush forests. The southernmost temperate eastern North American serpentine barren—Burke Mountain, GA—is a pine-grass savanna in which *Pinus palustris* (an isolated population) and *Pinus echinata* substitute for the *Pinus rigida* of the state line barrens. More remarkably, the aspect of much more distant serpentine barrens often closely resembles the appearance of the sites in Pennsylvania and Maryland. For example, Gasquet Mountain, CA, has a pine-grass savanna dominated by *Pinus jeffreyi, Pinus monticola, Festuca idahoensis* and *Poa piperi.* The presence of savanna on serpentine may not seem remarkable in California where oak savanna is one of the most widespread natural community types. However, Gasquet Mountain stands adjacent to coastal redwood forests and the serpentine barrens there, on average, receive more than four times the annual rainfall (Goforth 1984) as those in Pennsylvania and Maryland!

A paper published after this symposium places serpentine maidenhair in *A. aleuticum* (Rhodora 93:105–121).

An amazingly large proportion of the plant life at Gasquet Mountain looks quite familiar to an eastern serpentine devotee. One is struck by the high degree of convergence in phylogeny—some higher taxa appear to be "preadapted" for life on serpentine—and in morphology—one sees similar, apparently adaptive traits across a wide phylogenetic spectrum. *Phlox adsurgens* is strongly reminiscent of *Phlox subulata, Senecio macounii* looks like *Senecio anonymus,* and the serpentine endemic *Lilium bolanderi* closely resembles *Lilium philadelphicum.* The eastern naturalist may spot a plant that looks very much like *Asclepias verticillata* and, on finding a flower, discover it to be a lavender-rayed composite instead, *Erigeron foliosus* var. *confinis.*

Despite the similarities, many species appear totally unfamiliar to an easterner. For example, the flowers of *Calochortus tolmiei* (Liliaceae) have purple anthers surrounded by large blunt white petals covered with hundreds of projections resembling tentacles. The rare *Sedum laxum* subsp. *heckneri* is a sprawling succulent with dramatic upright candelabras of large pink and white flowers. *Darlingtonia californica,* a pitcher plant, has insectivorous leaves up to 60 cm tall that look like a cross between a rearing cobra and a giant banana slug. These and many other stunningly unfamiliar plants remind the eastern naturalist that the California serpentines are far larger in area and have been less buffeted by severe climate changes during the Pliocene and Quaternary compared with those in Pennsylvania and Maryland, allowing the processes of colonization and evolution greater scope in generating diversity.

Even within the flora of the temperate eastern North American serpentine barrens, convergence in morphology across taxa is striking. For example, the basal rosette habit is well developed in species from a wide range of families. *Arabis lyrata* (Brassicaceae), *Aster depauperatus* (Asteraceae), and *Panicum sphaerocarpon* (Poaceae) all have basal rosettes that are nearly identical in diameter, height, and general aspect. *Asclepias verticillata, Phlox subulata,* and *Polygonum tenue* have linear leaves atypical of their respective families and genera. These and other morphological traits such as leaf pubescence (*Cerastium velutinum*) and succulence (*Talinum teretifolium*) are most often associated with hot or dry habitats. Although the serpentine barrens are not dry, the rocky glades inhabited by all the plants listed in this paragraph can be quite hot in summer. Infrared radiation reflected and re-radiated from bare shales, granites, limestones, serpentine, and other rock types commonly occurring with little or no soil cover may well have been the selective force favoring characteristics such as basal rosettes, linear leaves, pubescence, and succulence.

SOIL FACTORS. But why is the rock bare in the first place? In regions of high rainfall such as Pennsylvania and Maryland, what prevents weathering and biological processes from covering serpentine with a thick layer of soil and vegetation as is the case with virtually all neighboring bedrock formations? Before considering these important questions, I will address one that is more fundamental. Soil does cover the bedrock beneath the other types of serpentine vegetation besides that growing on exposed rock or glades—the serpentine prairies, savannas, woodlands, and minerotrophic wetlands. Why are these types of vegetation still quite different from nearby vegetation on soils weathered from non-serpentine bedrock?

Most explanations focus on mineral nutrient conditions in soils weathered from serpentine bedrock. Serpentine soils have exceptionally low levels of nitrogen, phosphorus, potassium, and calcium—the minerals needed by plants in greatest quantity. The soils are also exceptionally high in nickel, chromium, and cobalt—metals known to be toxic to plants in high concentrations. However, experiments conducted by manipulating these factors in ordinary soils have failed to show a consistent link between any one of them and the species-specific effects of actual serpentine soils on plant growth and survival (Proctor and Woodell 1975; Brooks 1987).

Arthur Kruckeberg's experiment (1954) with plants from serpentine and non-serpentine populations of *Phacelia californica* is one of several studies that point to the magnesium: calcium ratio as the main factor limiting plant growth on serpentine sites. Ordinary soils typically have approximately one or two exchangeable calcium ions for every exchangeable magnesium ion. In serpentine soils the ratio is dramatically reversed. A survey of 156 serpentine soil samples from four continents showed a mean of 7.5 exchangeable magnesium ions for every exchangeable calcium ion (Proctor and Woodell 1975); Mg:Ca ratios of 20–100 are common and at least one sample has exceeded 300 (Brooks 1987).

Apparently many plant species, especially plants that are capable of fast growth, are physiologically "confused" by an excess of magnesium relative to calcium. Their calcium-handling enzymes may begin to bind with magnesium under conditions of magnesium abundance combined with calcium deficiency (Proctor and Woodell 1975). Even though magnesium is an essential plant nutrient (it forms the core of the chlorophyll molecule), at high concentrations or in combination with calcium deficiency it interferes with the uptake of other minerals or acts as a toxin, or both, leading to retarded growth, disease, or death.

Little is known of the physiological mechanisms that enable certain plants to handle high magnesium:calcium ratios. Presumably some have means of preventing magnesium from substituting for calcium. For example, some plants growing on serpentine may have highly discriminating versions of the enzymes responsible for calcium uptake, calcium transport, and the assembly of calcium-bearing biochemicals.

There is a common misconception that plants apparently restricted to serpentine habitats actually require serpentine soils. To the contrary, virtually all serpentine plants grow better on ordinary soils than they do on serpentine soils in pots or gardens where potential competitors are absent. The key to this paradox is a trade-off, apparently universal in the plant kingdom, between tolerance of nutrient deficiency and maximum growth rate (Chapin 1980). Constrained by the incompatibility of key physiological and morphological traits, members of a species can be good at tolerating nutrient scarcity or other nutrient stresses such as high magnesium:calcium ratio or they can be good at growing rapidly where nutrients are abundant or normally balanced, but not both. An inherently low upper limit on growth rate apparently is a side effect of the adaptations enabling plants of some species to grow under difficult nutrient conditions (Chapin 1980). Plants that can take advantage of nutrient abundance by growing fast and quickly depriving their neighbors of sunlight usually die in situations of nutrient stress. Thus, certain plants that are tolerant of nutrient stress can achieve competitive dominance on serpentine soils despite their low growth rates. They grow somewhat faster on nonserpentine soils but not fast enough to prevent succumbing to shading and crowding by much faster-growing plants that are *in*tolerant of nutrient stress.

Other factors may be important in limiting the local distributions of some plants to serpentine sites. For example, even though one might expect plants with nitrogen-fixing root symbionts to have a competitive edge in generally high-light, low-nitrogen environments such as the serpentine barrens, very few such plants are present (exceptions on the Pennsylvania and Maryland barrens are *Cassia fasciculata* and the introduced *Robinia pseudoacacia*). Some scientists have attributed this paradox to exceptionally low concentrations of molybdenum in serpentine soils (Walker 1948; White 1967). Molybdenum is the central ion in the enzyme employed by nitrogen-fixing bacteria and actinomycetes to reduce N_2 (atmospheric nitrogen) to NH_4+ (ammonium) usable by plants.

At least one investigator has suggested that there may be exceptions to the rule that serpentine plants grow better on ordinary soils than on serpentine soils. T. M. Tadros (1957) assayed the growth responses of a serpentine-restricted species in California, *Emmenanthe rosea* (Hydrophyllaceae), to serpentine and non-serpentine soils with half of each soil type exposed to enough heat to kill all microorganisms. The plants thrived on sterilized non-serpentine soils but failed to germinate on those that were not sterilized. The scientist hypothesized from this result that the serpentine-restricted species lacks innate resistance to some fungal pathogen of seedlings but that it is protected in its native habitat by the fungus's intolerance of serpentine conditions.

The hypothesis to my knowledge remains untested but it is an appealing idea. One of the most common causes of plant mortality is damping-off—a generic term for lethal attacks upon seedlings by various fungi. If such fungi avoid serpentine soil then they are not capable of selectively favoring resistance in potential host populations growing on serpentine. It follows that plant populations living entirely on serpentine and not interbreeding with populations living off serpentine could lose resistance to fungal attack by genetic drift. In this way, hypothetically, entire plant populations could become obligate serpentine dwellers.

Conservation Threats

So far I have reviewed a number of explanations for why the vegetation of serpentine barrens is so distinct from the surrounding plant life. But none of these explanations has addressed why the soil is thin and why there is often much bare rock on the barrens. It is true that the rate of plant growth on the barrens and the resulting rate of organic matter production are slow on the barrens relative to adjacent communities. However, soil formation depends on net organic matter accumulation, a function of both production and decomposition (Olson 1963). Areas free of soil should result only if serpentine conditions impede rates of plant growth more than they impede rates of decomposition. Little evidence exists to support or refute this hypothesis. In order to establish a foundation for what I believe is a more compelling explanation, I will take a short detour from biology and focus attention on conservation issues. What are the threats to this unique ecosystem in the eastern USA?

MINING AND QUARRYING. Pennsylvania and Maryland's serpentine outcrops were the world center of chromium mining in the late nineteenth century, when the main use for chromium was as a pigment in paint. Other minerals including talc, asbestos, and corundum as well as building stone were also extracted commercially. The serpentine barrens at Gasquet Mountain, California, have been seriously threatened by a proposed large-scale nickel mining operation. Currently there is a huge active serpentine quarry in southern Lancaster County producing crushed stone for concrete and asphalt paving.

Serpentine barrens conservation in Pennsylvania began after a plea from neighbors of Goat Hill worried about a proposal to strip-mine the rock there. To date, land totalling 278 ha has been acquired for the Goat Hill serpentine barrens nature preserve by The Nature Conservancy (a private organization dedicated to conserving biological diversity by identifying the best remaining occurrences of natural communities and rare species, protecting the land, and redressing any adverse effects of human land use).

DEVELOPMENT. Northern Chester County and central Delaware Counties, PA, are littered with more than a dozen small dead and dying serpentine barrens, eaten away by housing developments, two golf courses, and other types of intensive land use. Until recently, serpentine barrens have enjoyed a modest level of natural protection: the soils are poor for growing crops and they usually fail to meet percolation requirements for septic tank construction. But newer high density developments and the gradual coalescence of the patchwork of suburban sprawl make sewer systems economically feasible. Equipped with sewers and treatment plants, serpentine barrens suddenly become developable. Riddle Hospital currently plans to build a nursing home atop one of two remaining barrens in Delaware County, which once harbored at least nine such sites. In response to protest by citizens and the Pennsylvania Department of Environmental Resources, construction plans were revised to show a set-aside—a tiny patch labelled "serpentine aster"—with recontoured ground, landscape planting, and a wing of the proposed building still occupying most of the actual serpentine barrens community. This plan exemplifies what might be termed the flower-garden approach to rare species conservation, doomed to failure. No law exists in Pennsylvania that can be invoked to protect this rare natural community or the globally rare species that lives there.

INVASION BY NON-SERPENTINE VEGETATION. The other remaining serpentine barren in Delaware County, Pink Hill, is protected from development as part of the Tyler Arboretum. But is protection from bulldozers enough? A closer look suggests otherwise. *Robinia pseudoacacia* has invaded the serpentine prairie at Pink Hill and appears to be spreading. It was introduced to the region from its pre-European settlement range in the Appalachian and Ozark mountains and the Ohio valley (Fowells 1965). Without intervention this aggressively invasive tree would doubtless cover tiny Pink Hill's entire prairie area in only a few years.

Even at Goat Hill, with a barrens area almost 100 times larger than Pink Hill, there are signs of invasion by species not considered as characteristic members of the serpentine flora. Around the fringes of the barrens, large *Pinus rigida,* many dead or dying, stand among young woods dominated by *Acer rubrum, Prunus serotina, Robinia pseudoacacia,* and *Ailanthus altissima.* An aerial view of the heart of the Goat Hill barrens reveals that the *Pinus rigida* canopy is nearly closed across most of the savanna. Prairie openings—common on other barrens of the state line group—are nearly absent at Goat Hill.

A comparison of historic and modern aerial photos reveals a dramatic pattern. An aerial photo taken at Pilot Barrens, Cecil County, MD, in 1938 shows vast areas of open prairie and sparse savanna. A photo of the same site taken in 1988 presents quite a different picture. Only one comparatively small area of prairie remains. Most of the area formerly in barrens now has closed-canopy forests of *Pinus virginiana.*

Why do the barrens appear to be declining or even disappearing in just a few decades when we can infer with confidence from the distributions of so many indicator plant species that the communities have existed for thousands of years? Searching has turned up numerous clues.

IMPORTANCE OF FIRE IN PERPETUATING BARRENS COMMUNITIES

Charred bark is a common sight on *Pinus rigida* of serpentine savannas and glades. Trunks and limbs of many *Pinus rigida* also sport a green "fur" of adventitious shoots. It is not uncommon to see *Quercus marilandica* and *Quercus stellata* with leaves bunched tightly around a stout trunk on disproportionately small twigs, with larger branches either dead or absent. Adventitious shoots spring from epicormic buds present in these particular pine and oak species but not in other tree species living in the region. In the pine barrens of the New Jersey coastal plain and at certain other sites, these buds are most often released from dormancy by fire.

The serpentine dominant *Sporobolus heterolepis* is a bunch grass common in the shortgrass prairies of the Dakotas, Nebraska, and other parts of the West. Bunch grasses build up masses of living and dead plant tissue around their crowns. The material acts as effective insulation shielding crown meristems from the heat of prairie ground fires, which occur frequently in shortgrass country. Furthermore, seeds in the soil from this and some other prairie species reportedly break dormancy and germinate most profusely immediately following a fire.

A study conducted in the 1960's and 1970's confirmed the implications of numerous fire-adapted traits in the serpentine flora. Botanist Gary Miller undertook a vegetation distribution analysis on a serpentine barren in southern Lancaster County, PA, for his master's thesis. Fortuitously, a major wildfire swept through many of his sampling plots five years after he had collected species abundance data. In resampling six and nine years post-fire, he found increases or little change in cover by many of the characteristic serpentine species, including the addition of previously unrecorded *Aster depauperatus.* He also found substantial decreases in cover by species more commonly found on non-serpentine soils, including the virtual disapperance of formerly abundant *Pinus virginiana* (Miller 1981).

Many plant species inhabiting regions or natural communities where wildfires are common have traits enabling them to survive a fire if it is not too severe. Some of these species are even suspected to have traits that *facilitate* relatively cool, fast-burning fires (Mutch 1970; Platt, Evans and Rathbun 1988). These may include air pockets, volatile resins, resistance to absorption and retention of moisture, and other flammability-enhancing traits in cast-off leaves and other tissue. Vegetation dominated by species with such characteristics tends to ignite, especially in the dormant season, at any provocation—lightning, a discarded cigarette, a spark from burning trash or a campfire—while ordinary vegetation is likely at most merely to smolder except during severe drought. Species acting as "ecological arsonists" may have hit upon, evolutionarily, a means of eliminating competitors of fire-intolerant species.

The barren-dwelling plants have apparently undergone an evolutionary trade-off. In acquiring the abilities to tolerate infertile soil and frequent wildfire, they have sacrificed the ability to grow fast and aggressively compete for sunlight (Chapin 1980; Grime 1977). Thus, the vegetation of the serpentine barrens is fire-dependent. In the prolonged absence of fire, mesic vegetation may invade serpentine barrens producing litter that readily absorbs and retains moisture, is resistant to igniting and carrying flame, and decays to form soil rich in organic matter. The enriched soil may shift the entire system over to a different self-perpetuating community dominated by non-barren plant species (Streng and Harbcombe 1982).

Frequent wildfire would explain the presence of bare rock and thin soil, two of the key characteristics of the barrens that may be crucial to maintaining the distinctiveness of the vegetation. Fire turns carbohydrates, the largest constituent of organic matter by volume, into carbon dioxide, water vapor, and smoke. The organic matter that is so important to building soil and holding it in place against erosion is periodically lost from the system in massive quantities. Exceptionally hot fires, for example, where the wood of large trees provides abundant fuel, may burn organic matter even after it has been incorporated into soil. Thin soils and bare rock most likely result from the interaction of fire and water erosion.

FIRE SUPPRESSION. Accounts from the *Daily Local News,* a Chester County, PA, newspaper, give clues about why the serpentine barrens are shrinking. From 20 April 1908: "A forest fire is raging in the pine barrens just to the south of Oxford. . . . No effort is being made to stop the progress of the fire, it being allowed to burn itself out." From 7 May 1962: "More than 300 volunteers from 14 fire companies were called into the battle to *save the* *area,* known as the Barrens . . ." (italics are mine). Sometime between 1908 and 1962, active fire suppression came to the rural areas where eastern serpentine barrens occur.

Not all fire suppression involves pumpers and hoses. An aerial photograph of Chrome Barrens, Chester County, PA, shows a plethora of inadvertent firebreaks including the road bisecting the barrens, driveways, farm fields, pastures, and lawns. Long-time neighbors recall only one relatively small wildfire at Chrome Barrens in the past 50 years.

PRESCRIBED BURNING AS A MANAGEMENT TOOL. What can be done about this most subtle of threats to the integrity and persistence of the eastern serpentine barrens? At the state line barrens, staff of The Nature Conservancy in Pennsylvania and Maryland have embarked upon a stewardship program designed to counter the effects of decades of fire suppression and to restore periodic fire to its rightful position as an integral force in serpentine community dynamics. A similar program is underway at Soldiers Delight by the Maryland Natural Heritage Program, an agency of the state Department of Natural Resources.

The program starts with research, beginning with an assay of herbaceous and woody plant species abundances on permanently marked sampling plots. The next phase is prescribed burning, the carefully planned and controlled use of fire by trained experts under optimum conditions of wind, humidity, fuel moisture, and other critical factors. The ignition, spread and movement of the fire is tightly controlled to burn a precisely specified area. Burn units include only half of the vegetation sampling plots, allowing researchers to tease apart the effects of fire from other influences on vegetation such as insect or disease outbreaks, weather, soil nutrients and soil moisture.

Prescribed burning accomplishes several ends. It provides information critical to the long-term protection of fire-dependent systems by allowing experimental evaluation of the effects of fire on species abundances and distributions. By imitating the effects of wildfire it restores a vital component of the natural disturbance regime to communities that show evidence of decline due to fire suppression. It also reduces the natural fuel load and with it the threat of catastrophic, uncontrollable wildfire.

In some places, many tons per acre of highly flammable natural fuels have accumulated due to the artificial suppression of fire. Ironically, in a community of plants with traits conferring high flammability, fire prevention in the short term increases fire hazard in the long term. This is a lesson resource managers have learned over and over the hard way. The principle made the news after the 1988 fires at Yellowstone National Park, where decades of fire suppression had resulted in massive fuel build-up which in turn led to unusually hot and widespread fires during an ordinary episode of drought. Yellowstone covers a large enough area and is so sparsely settled that land managers have the option of allowing wildfires to burn unimpeded. In an area as densely populated as the northeastern USA, a "let it burn" wildfire policy is virtually unthinkable. Here, prescribed burning offers a practical and environmentally sound way of preventing massive fuel build-up in fire-dependent ecosystems and staving off catastrophic wildfires.

The first of many planned ecological burns at the state line barrens took place in fall, 1990, at Pilot Barrens under the direction of Conservancy biologist Mary Droege. The first burn at Chrome Barrens, to be led by Conservancy biologist Michael Batcher, and the second burn at Pilot Barrens are planned for late 1991-early 1992.

OTHER FIRE-DEPENDENT NATURAL COMMUNITIES. Serpentine barrens are not the only natural communities considered to be fire-dependent in the mid-Atlantic region of eastern North America's deciduous forest biome. New Jersey's pine barrens, especially the dwarf forests known as the Plains, are probably the most extensive and best known example. The Albany Pine Bush and Long Island's pine barrens in New York exhibit the syndrome of fire-dependency. All are sites of active prescribed burning programs conducted by state agencies, The Nature Conservancy, and other groups charged with the stewardship of natural areas.

In Pennsylvania a few small fragments of limestone glades and prairies have escaped cultivation, including communities characterized by *Dodecatheon meadia* and *Poa compressa* at Conococheague Bluffs, Franklin County, and by *Bouteloua curtipendula* at Westfall Ridge Prairie, Juniata County. The Appalachian sand barrens near Gatesburg in Centre and Huntingdon Counties and the Appalachian shale barrens of Bedford, Fulton, and Huntingdon Counties also probably have varying degrees of fire-dependence.

The Pocono till barrens in northeastern Pennsylvania are the state's most extensive fire-dependent community. They cover an area several times greater than the serpentine barrens and have similarly rich complements of rare species. The Pocono barrens lie overtop the state's largest intact deposit of Illinoisan glacial till, a remnant of the second-most recent glacial advance 140,000 years ago, in Monroe and Carbon Counties. Dominant and characteristic species of these barrens include *Pinus rigida, Quercus ilicifolia, Rhododendron canadense, Kalmia angustifolia, Vaccinium angustifolium, Oryzopsis pungens, Carex polymorpha, Carex vestita,* and *Amianthium muscaetoxicum.*

Like serpentine soils, the soils weathered from Illinoisan till on the Pocono Plateau have unusually low mineral nutrient concentrations. Like serpentine vegetation, the plant life of the Pocono till barrens is well watered but has the aspect of vegetation native to a far drier region. Like the serpentine barrens, the Pocono till barrens are prone to wildfire and many of the plants exhibit traits associated with fire dependence. The community is so distinctive that its one large and several small occurrences on the Pocono Plateau are considered to be the planet's entire inventory of the type. It is host to many rare species including the globally rare and endangered *Carex polymorpha.* At least seven globally rare and endangered insect species inhabit the Pocono barrens including the only insect species whose entire known range is confined to Pennsylvania—the flypoison bulb-borer moth (*Papaipema* sp. 1), which feeds on the highly toxic root of *Amianthium mascaetoxicum.*

CONCLUSIONS

Fire-dependent natural communities make up less than a tenth of one percent of Pennsylvania's total area, yet they include about 10% of the state's known occurrences of globally rare plants and animals (species or subspecies represented by 20 or fewer total populations) and natural communities ranked as having global significance. Unlike many southern, midwestern and western states, Pennsylvania has almost no recent tradition of using fire in farming, forestry or wildlife management. Much of what people in Pennsylvania and other northeastern states typically know about wildfire they learned from Smokey the Bear. Prescribed burning is the best way to achieve certain important research, conservation, and wildfire prevention goals but it cannot succeed without increased awareness and acceptance by government officials, neighbors of fire-dependent natural areas, and the general public. Unfortunately, the bias that all fires are tragedies permeates the public perception and is often exacerbated by the style and content of journalists' coverage (Smith 1989).

The long-term persistence of Pennsylvania's rarest and most unusual terrestrial communities depends on scientists and resource managers adopting fire as a tool of biodiversity conservation. It also depends on a convincing, well targeted campaign by knowledgeable and concerned people to spread the word about the ecological importance of fire.

ACKNOWLEDGMENTS

I thank Ann Rhoads and Steve Demos for helpful comments on an earlier version of the manuscript. Thanks are also due Kevin Dougherty, Mary Droege, George Harlow, John Morton, Bill Murdy, Gail Newton, Carol Palmer, Dale Schweitzer and Conrad Smith for information on particular topics.

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Bartonia No. 57, Supplement: 75–92, 1993

Selected Rare and Historical Vascular Plants of Delaware

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Botanists and zoologists with the Delaware Natural Heritage Inventory (DNHI) are responsible for surveying the entire state for rare species and significant natural communities. A major challenge of this work is to assess the rare flora and fauna, a task made even more difficult by the dynamic nature of the biota. A formerly common species may become rare due to habitat destruction, and conversely, as more field work is undertaken, a species previously believed rare may be found to be more common.

DNHI has developed a list of rare native plants (McAvoy 1993). The list, which is updated annually, depends on input from many sources: experts in the field, literature, herbarium collections, and field surveys. Tatnall (1946) provided substantial, and important, historical information on the Delaware flora including species he considered rare or no longer extant. Phillips (1978) was unable to relocate 338 species reported by Tatnall. Tucker et al. (1979) designated 450 taxa as rare, endangered, possibly extirpated, or status uncertain, and recognized the need for more thorough field work.

Over the past five years, intensive botanical field work has resulted in new information on the distribution and abundance of many species. These data are used to assess status. Although information from literature sources and herbarium collections form the framework, the development of the list is driven by intensive field surveys.

When a rare species is discovered, detailed information is gathered on population ecology, areal extent, co-occurring species, habitat description, etc. Locations are mapped on USGS topographic maps, and the record of the species is entered into the DNHI database (DNHI 1993). Herbarium voucher collections are made with prudence (i.e. collecting is avoided if population is small, or species is known from only a few populations).

Of the 2259 taxa listed by Tatnall (1946) as native, naturalized, or otherwise occurring on the Delmarva Peninsula; nearly 93% were present in Delaware (Tucker et al. 1979). Inventory work undertaken since Tatnall's publication, and particularly during the past five to ten years, has shown that many of the remaining 7% are also present in the state (e.g. *Alopecurus aequalis, Hypericum drummondii, Juncus torreyi, Mecardonia acuminata, Passiflora incarnata*). In addition, many other species which have been found in Delaware since 1946, are also new to the flora of the Delmarva Peninsula (e.g. *Carex projecta, Isotria medeoloides, Listera australis, Panicum hirstii, Pellaea atropurpurea, Sanicula trifoliata, Schizaea pusilla*).

The information presented in this paper has been updated since the 1991 symposium to reflect new data from 1991 and 1992 field surveys. Nomenclature generally follows Gleason and Cronquist (1991).

RARE SPECIES

On-going botanical field surveys in potentially suitable habitats and at historical sites throughout the state suggest that the following species are rare in Delaware. All those discussed below are ranked S1 (extremely rare; 5 or fewer known occurrences in the state) by DNHI. A total of 296 species are currently included in this category; an effort was made to select for inclusion here, species for which rarity could be well substantiated.

Federal status designations are included (US Fish and Wildlife Service 1991a, 1991b, 1992a, 1992b, 1992c): LE = Listed Endangered; LT = Listed Threatened; PT = Proposed Threatened; C1 = Candidate, Category 1; C1* = Taxa which are believed to be extinct but persuasive documentation has not been made; C2 = Candidate, Category 2.

Actaea alba (L.) Miller (= *A. pachypoda* Ell.), white baneberry. Tatnall (1946) considered this species to be "rare, in rocky woods along Brandywine Creek," and cited several collections: (1) Wills Rock, Wilmington, 1866 and 1893 (A. Commons s.n., PH), 13 May 1899 (W. M. Canby s.n., DOV), and along the railroad at Wills Rock, 13 May 1944 (R. R. Tatnall 5085, DOV); and (2) Rockford Woods, 14 May 1897 (E. Tatnall, DOV). It is currently known from two sites in the Brandywine drainage of the Piedmont Province: (1) Rockland Park, Wilmington, several dozen plants were observed on steep slopes above the Brandywine Creek in 1988 (Ebert et al. 1990), this may be a relocation of E. Tatnall's 1897 Rockford Woods site; and (2) near Hoopes Reservoir, one plant was observed in a mature hardwood forest in 1991 by J. Ebert & J. Holt.

Amianthium muscaetoxicum (Walt.) Gray, fly-poison. Tatnall (1946) considered this plant to be "infrequent." Historical collections include the following: (1) along Penrose Branch, 5.5 miles west of Dover, 24 Jun 1930 (H. H. Hanson s.n., DOV); (2) near Greenbank, low ground, Work horse farm, 8 Jun 1922 (J. P. Otis s.n., PH); (3) between woods and Greenbank farm, low meadow, 2 Jul 1923 (J. P. Otis s.n., PH); (4) Mt. Cuba, dry woods, 8 Jul 1875, (A. Commons s.n., PH), 19 Jul 1891, (J. B. Brinton s.n., PH) and 24 Jun 1906, (S. S. VanPelt s.n., PH). It is currently known from five New Castle Co. sites, all in the Red Clay Creek drainage: (1) near Mt. Cuba, over 80 individuals were observed in a dry oak-beech woods, discovered in 1989 (Ebert et al. 1990); (2) near Wooddale, a small population of several plants was observed in a wooded ravine of mixed hardwoods in 1991 by J. Ebert & J. Holt; (3) near Wooddale three plants were observed in a mature mesic forest dominated by *Fagus grandifolia* in 1991 by J. Ebert & J. Holt; (4) near Ashland, along small tributary, four plants were observed in a mature woods of *Fagus grandifolia, Quercus rubra, Hamaemelis virginiana,* and *Viburnum acerifolium* in 1991 by J. Ebert & J. Holt; and (5) within 0.25 mile of previous site, more than 30 individuals were noted growing within 10 meters of a small tributary of the Red Clay Creek in 1991 by J. Ebert & J. Holt.

Arenaria caroliniana Walter, pine barren sandwort. According to Tatnall (1946) this plant was known from "a single collection: near Little Hill Church, 0.5 mile ne of Pepperbox, in dry pine barrens," (Commons, 5 Aug 1874, PH). The pine barren sandwort had been ranked SH by DNHI until several hundred plants were found in the dunes at Cape Henlopen State Park by F. Hirst & R. Wilson in 1992.

Asclepias lanceolata Walt., few-flowered milkweed. Tatnall (1946) considered this milkweed to be "frequent on beaches and in salt marshes" of Kent and Sussex counties. Recent field surveys conducted by DNHI botanists have resulted in its discovery at four Sussex Co. sites: (1) near Bethany Beach, a small population was observed in 1989 in an interdunal swale with several other state-wide rare species, *Eupatorium leucolepis, Fuirena squarrosa,* and *Vaccinium macrocarpon* by F. Hirst. In addition three distinct populations were located in the Assawoman Bay Wildlife Area; one in a coastal plain pond, one at the edge of a pond and along a woods road, both discovered by F. Hirst in 1989 and 1991; and the third at the edge of a brackish high-marsh within the general area of other rare species (*Agalinis maritima, Centella erecta,* and *Juncus roemerianus*), discovered in 1992 by W. McAvoy. All populations consisted of less than 10 individuals.

Asclepias rubra L., red milkweed. Tatnall (1946) reported this species to be "infrequent, in all three counties of Delaware." There are two known extant populations on the Coastal Plain: (1) near Dagsboro, less than 10 individuals were observed, with other state rare species (*Paspalum dissectum, Platanthera blephariglottis, P. lacera, Rhynchospora gracilenta, R. microcephala*) along an approximately 0.5 mile long swale in a powerline right-of-way in 1984 by F. Hirst: and (2) south of Woodland Ferry, a population of about 50 plants was observed along the roadside adjacent to a tidal red maple swamp in 1989 by R. Radis.

Asplenium trichomanes L., maidenhair spleenwort. Tatnall (1946) stated that this fern was "rare, in moist rock-crevices along the Brandywine and Red Clay Creeks. . . . Not collected since 1893." Tucker et al. (1979) considered it extirpated, and at a December 1990 meeting of DNHI botanists it was decided to rerank this species from SH to SX. However, that decision was premature, as J. Holt & J. Ebert located three small populations of this fern growing on rocks above the Brandywine Creek near the Hagley Museum in April 1991. This site is a relocation of the Soda House Woods site discussed by Fleming (1978).

Bidens bidentoides (Nutt.) Britton var. *bidentoides,* bur-marigold, C2. This plant has rather narrow habitat requirements, i.e. fresh to slightly brackish tidal mud flats (Ferren and Schuyler 1980). Tatnall (1946) stated that it was "infrequent" on the Delmarva. It is known from four extant sites, although population viability is tenuous, and several historical sites. It is found growing in tidal mud amid rocks and concrete blocks from near Delaware City to just below the PA state line, with the majority of plants having been observed in and near New Castle. Historically, it has been collected on several occasions along the Delaware River, the Brandywine Creek, and possibly along the Appoquinimink River (W. M. Canby, undated PENN; W. M. Canby Oct. 1865, PENN; ex Herb. E. Tatnall 1865, GH; Ferren 1159 and 1107, PH; R. Tatnall s.n., PENN). Population numbers in 1989 and 1990 ranged from a few individuals to less than twenty per site. Surveys in the summer and fall of 1991 located only one individual, a seedling (K. Clancy, B. McAvoy, A. E. Schuyler pers. observs.). This species is threatened throughout its range by dredging, filling, bulkheading, salinity increases, and pollution. A recent oil spill on the Delaware River (Presidente Rivera oil spill of 1989) resulted in many individuals of *Bidens* being covered in oil (R. Radis pers. comm.) and during surveys in September, 1991 a thick layer of oil-soaked mud was discovered at a site near Claymont (K. Clancy and B. McAvoy pers. obs.).

Botrychium matricariaefolium A. Br., chamomile grape-fern. This species was not reported to occur on the Delmarva by Tatnall (1946). It is now known from four Delaware sites: (1) Pike Creek Valley near Rte 2, in 1989 eight individuals were counted in a young tulip poplar woods (Ebert et al. 1990), this population may already have been destroyed by a housing development (B. McAvoy pers. comm.); (2) White Clay Creek Preserve, several dozen plants were observed in a young red maple woods in 1988 (Ebert et al. 1990); (3) Brandywine Creek Valley near Rockland, only one sporophyte was observed at the interface between mature hardwood forest and young maple woods in 1989 (Ebert et al. 1990); and (4) adjacent to the Christiana River near Newark, three sporophytes were observed, growing with *B. virginianum,* in a mature beech-tulip woods in 1991 by J. Ebert & J. Holt.

Cacalia atriplicifolia L., pale Indian plantain. Tatnall (1946) reported this species to be "infrequent in pastures, thickets and open woods of the Piedmont Province; rare on the Coastal Plain. . . ." It is known from several historical collections from New Castle Co.: (1) field near Thompson Station, 6 Aug 1932, (R. R. Tatnall s.n., PH); (2) Kiamensi, 9 Sep

1901, (A. Commons s.n., PH); and (3) Greenbank, in woods, 13 Sep 1884, (A. Commons s.n., PH). The latter two sites occur near each other in the Red Clay Creek drainage. Since 1988 this rare composite has been discovered by J. Ebert & J. Holt at three localities in the state: (1) along the Red Clay Creek north of Wooddale, eight plants were observed growing in an old field; (2) Brandywine Creek, several dozen plants were observed along the floodplain near Ramsey Run; and (3) Sandy Branch east of MD line, nearly 100 plants were observed on slope above the creek.

Chamaelirium luteum (L.) A. Gray, devil's-bit, blazing star. This species was considered "infrequent, in rich woods and thickets of the Piedmont province" by Tatnall (1946), and was listed by Tucker et al. (1979) as "possibly extirpated. . . ." Historical collections include: (1) Wilmington, thickets, 25 May and Sep 1896, (A. Commons s.n., PH); (2) Brandywine, rocky woods, May 1843 (Rev. J. H. B. s.n., PH); (3) Mt. Cuba, 3 Jun 1894 (A. John s.n., PH). According to Tucker et al. (1979) the species was last collected in Delaware in 1938, however, during the 1992 field season, three plants were observed in disturbed habitat along a road bank in northern New Castle Co. by J. Ebert & J. Holt.

Coreopsis rosea Nutt., pink tickseed. This species was reported by Tatnall (1946) to be "frequent . . . from New Castle to Sussex . . . counties." Phillips (1978) stated that it was not found on the Delmarva, and Tucker et al. (1979) concluded that the species needed further field work to determine its true status in Delaware. According to Tucker et al. (1979) there were seven historical populations, the most recent from 1938, distributed in New Castle, Kent, and Sussex counties. At one time, Ellendale wet meadow was home to the pink tickseed (Dill and Tucker 1982), but searches at the site since 1984 have proved unsuccessful. Recent field surveys have resulted in its discovery at three Sussex Co. locations: (1) near Lewes, two populations were found in separate coastal plain ponds (Delmarva Bays), by D. Boone & F. Hirst in 1982, and F. Hirst in 1988; and (2) near Milton, an exceptionally vigorous population, estimated at >10,000 in 1990, was discovered in 1982 by D. Boone and F. Hirst in a pristine coastal plain pond.

Corydalis flavula (Raf.) DC., yellow corydalis. Tatnall (1946) considered the species to be "locally abundant in rocky woods . . . rare in northeastern New Castle Co." and cited one historical collection: Naamans Creek, below Harvey (Arden) Station, (Commons and Tatnall, 27 April 1894, PH). Although Tucker et al. (1979) mentioned two populations seen in 1971, they believed the plant to be extirpated in the state. There is one known population: near White Clay Creek, north of Newark, thousands of individuals were observed along a nearly 1.0 mile length of terrain, growing with a number of alien species (*Cerastium vulgatum, Stellaria media, Valerianella locusta*) in 1992 by J. Ebert & J. Holt.

Desmodium strictum (Pursh) DC., pine-barren tick-trefoil. Tatnall (1946) considered this species to be "infrequent, . . . from Caroline Co. to Worcester Co.," and did not include Delaware in the species' range. Nevertheless, since 1988, four populations have been discovered: (1) Nanticoke Wildlife Area, three populations of one, two, and over 200 individuals, respectively were discovered in xeric, sandy pine woods by C. Ludwig in 1988; and (2) near Nanticoke Wildlife Area north of Broad Creek, several dozen fruiting individuals were observed in dry sandy pine woods by F. Hirst in 1989.

Diervilla lonicera Miller, bush-honeysuckle. This species was reported by Tatnall (1946) to be "rare, in rocky woods of New Castle Co." Historical collections include: (1) Rattlesnake Run, Wilmington, 1 Jun 1844 ("G. W. T." s.n., DOV); (2) Mt. Cuba, 1873 and 1896 (A. Commons s.n., PH) and 29 Jun 1893 (E. Tatnall s.n., DOV); (3) Point Lookout, 0.5 mile nw of Granogue, 20 Jun 1937 and earlier collections (R. R. Tatnall 3425, DOV, G, PENN, PH); and (4) above Rockland, rocky woods along Brandywine, 8 May 1897 (A.

Commons s.n., PH). Since 1988 it has been discovered at two sites on the Piedmont: (1) along the Brandywine Creek west of Talleyville, a small population was noted in a rocky, steep-sloped *Liriodendron tulipifera* woods, discovered in 1988; and (2) northwest of Mt. Cuba, two plants were observed in a rocky mature oak-beech woods, discovered in 1989 (Ebert et al. 1990).

Dirca palustris L., leatherwood. Tatnall (1946) considered this plant to be "rare, in rich, rocky woods along Brandywine and Red Clay Creeks, New Castle Co." Historical collections include the following: (1) Mt. Cuba, 3 Jun 1864 (A. Commons s.n., PH) and at least seven other collections; and (2) west bank of Brandywine Creek, 0.25 mile below Henry Clay bridge, 10 Apr 1888 (R. R. Tatnall 1369, PH), and several additional collections made from, or near, this site. Intensive surveys during the past five years resulted in the 1989 discovery of a site near Mt. Cuba, one fruiting shrub was observed in 1992 in a mature mixed hardwood forest; this may be a relocation of Commons' 1864 site (Ebert et al. 1990).

Eleocharis rostellata (Torr.) Torr., small-beaked spikerush. This plant was considered to be "rare" by Tatnall (1946), who cited several historical collections: (1) Collins Beach, 20 Jun 1866 (A. Commons s.n., PH); and (2) Love Creek, near Rehoboth, 20 Jun 1926 (True s.n., PENN). This rare sedge is known from four extant sites: (1) Love Creek near Rte 24, a small population, surrounded on three sides by *Phragmites australis,* was observed in tidal brackish marsh in 1992 by C. Ludwig & B. McAvoy; (2) Angola Neck near Bookhammer Landing, an abundant and dominant species in more than 4 acres of a slightly brackish to freshwater bog-like habitat discovered in 1992 by C. Ludwig; (3) Assawoman Bay Wildlife Area, several thousand stems were observed covering approximately 6 acres of high tidal marsh by B. McAvoy in 1992; and (4) Angola Neck near Bookhammer Landing, more than 1000 stems was observed at edge of salt marsh by F. Hirst & R. Wilson in 1992. The Love Creek site may represent a rediscovery of True's historical site.

Equisetum fluviatile L., water horsetail. Tatnall (1946) considered this species to be "infrequent to rare" on the Delmarva and cited the following collections: (1) Bellevue, near Station, Jun 1868 (Commons s.n., PH); (2) Port Penn, 28 Jul 1884 (J. Carter s.n., PH); (3) south bank of Drawyers Creek, above DuPont Highway 1 mile north of Odessa, 4 Jul 1929 (R. R. Tatnall s.n., DOV); (4) streamlet west side of DuPont Highway, 1 mile north of Fieldsboro, 3 Jun 1939 (R. R. Tatnall 4188, DOV, PH). The last site is still extant. I followed Tatnall's directions precisely, and discovered this horsetail at the exact location specified. More than 100 stems were observed in a narrow mixed hardwood swamp forest adjacent to an emergent freshtidal marsh (K. Clancy 2617, 2625, DNHI Reference Herbarium).

Eriophorum virginicum L., tawny cotton-grass. Tatnall (1946) considered this species to be "infrequent," and intensive searches by DNHI botanists over the past few years would support that characterization. Since 1986, two sites have been discovered in Sussex Co.: (1) Angola Neck near Bookhammer Landing, a small population was observed in a narrow *Alnus maritima* dominated scrub-shrub wetland at the interface between a mixed forest and an emergent freshwater bog-like community by C. Ludwig in 1992; and (2) west of Frankford, in moist sandy soil, where it was observed associated with *Bartonia virginica, Eupatorium leucolepis, Rhynchospora microcephala, R. capitellata, Polygala lutea,* and *Juncus canadensis* (Naczi et al. 1986).

Eryngium aquaticum L., button snakeroot. This species was reported by Tatnall (1946) to be "frequent; ditches, rivers, beaches, dune hollows and swamps of the coastal plain, in fresh or brackish habitats." Recent intensive floristic surveys have resulted in its discovery at three (possibly four) Sussex Co. sites: (1) along Love Creek, near Rt 24, a large population covering approximately five acres occurs in fresh tidal marsh, discovered in 1992 by C. Ludwig & B. McAvoy; (2) along Burton Prong, near Burton Millpond, ca. 50 plants in bud and flower were observed at the edge of a brackish marsh, co-occurring with such species as *Baccharis halamifolia, Hydrocotyle verticillata* var. *verticillata, Phragmites australis, Rumex verticillatus,* and *Sabatia dodecandra* in 1992 by F. Hirst; and (3) Miller Neck, adjacent to Dirickson Creek, several dozen plants were observed in an open, freshwater bog-like habitat above salt marsh in 1992 by B. McAvoy. Associated species include: *Centella erecta, Cladium mariscoides, Eleocharis palustris, Carex crinita,* and *Sphagnum* sp. A possible fourth site is in the Assawoman Bay Wildlife Area north of Miller Creek, several plants were observed in relatively dry habitat (K. Clancy 2046, DNHI Reference Herbarium). Identification is tentative as these plants appear to be intermediate between *E. aquaticum* and *E. yuccifolium.*

Fimbristylis perpusilla Harper, Harper's fimbristylis, C2. This species was not reported for the Delmarva by Tatnall (1946). Until very recently this sedge was only known from Georgia (Kral 1983), however, field work in the last twelve years has resulted in discoveries in several southeastern states (Leonard 1981, Hirst 1983, Leonard 1987, Wofford and Jones 1988, Harvill et al. 1992). This species is sporadic and appears irregularly over the years; at one locale in Georgia it went nine years between appearances (Kral 1983). Populations in Delaware exhibit similar erratic fluctuations (F. Hirst pers. comm.). It is known from three Coastal Plain ponds: (1) west of Hartly, a small population was observed in a woodland pond in 1984 by F. Hirst, this population has not been seen here since its discovery; (2) in a pond east of Delaneys Corner, a small population restricted to the center of the pond was first discovered by F. Hirst in 1983 and subsequently observed in 1991 and 1992 (K. Clancy 2373, DNHI Reference Herbarium); and (3) west of Delaneys Corner, a small population was observed in a woodland pond in 1991 by B. McAvoy, no plants were observed in 1992, although the pond was flooded into October.

Hudsonia ericoides L., golden heather. Tatnall (1946) described this species as "rare, in dry sandy soil of the seacoast," and cited several collections: (1) Cape Henlopen, in 1895 and 1898, (A. Commons s.n., PH); and (2) along the railroad, 3 mile nw of Rehoboth, 30 May 1935, (R. R. Tatnall 2578, DOV, PH), and 16 May 1938, (R. R. Tatnall 3695, DOV). There are currently three known extant sites, all within the confines of Cape Henlopen State Park: (1) in dunes, several hundred plants were observed by F. Hirst in 1988; (2) in xeric sand dunes near the US Naval Reservation, only a few clumps were seen growing alongside *H. tomentosa, Lechea* sp., and *Panicum commonsianum* in 1992 by F. Hirst & R. Wilson; and (3) in maritime pine forest, a few plants were seen in 1992 by F. Hirst & R. Wilson.

Isoetes riparia Engelm., riverbank quillwort. This species was reported by Tatnall (1946) to have been "collected in tidal mud of Delaware River, at and north of Wilmington, by Commons, Canby and E. Tatnall, between 1862 and 1896; not seen since." Today, there are three known localities: (1) Delaware River near Delaware City, New Castle Co., between 50–100 plants were observed in mud of a brackish tidal marsh in 1988 by R. Radis, searches at this site in 1992 were unsuccessful; (2) along the Nanticoke River, near Middleford, Sussex Co., two distinct populations of ca. 20 plants, and between 50–100 individuals, respectively, were observed in the freshwater intertidal zone by F. Hirst in 1988. There appears to be ample habitat for this species, especially in light of its discovery along the Nanticoke River.

Isotria medeoloides (Pursh) Raf, small-whorled pogonia, LE. In Delaware this rare orchid is known from a single population near Blackbird State Forest, New Castle Co. where a few plants were observed in a young mesic oak-beech-hickory forest by M. McLaughlin in 1985. Since 1985, population numbers at this site have varied from 0–11 stems, no plants were observed in 1992.

Lachnanthes caroliniana (Lam.) Dandy, Carolina redroot. Tatnall (1946) stated that this species was "frequent in bogs and sandy swamps, Kent and Sussex counties." However, intensive surveys over the past five years indicate that it has suffered a decline since Tatnall's time. The species is now known from five Sussex Co. sites: (1) near Lewes, several hundred plants were observed in a coastal plain pond (Delmarva Bay) by F. Hirst in 1988; (2) near Milton, a large population of several thousand plants was observed in a pristine coastal plain pond by F. Hirst & D. Boone in 1982 and still extant in 1992; (3) near Robbins, 50–100 plants were observed in a wet clearing of a re-planted pine plantation by F. Hirst in 1989; (4) north of Georgetown, two distinct populations, located more than 1.0 mile apart in openings in wet pine woods, one with less than 10 plants, the other with several hundred plants, were discovered by F. Hirst & R. Wilson in 1990 and 1992.

Listera australis Lindl., southern twayblade. Tatnall (1946) did not list this species for the Delmarva. There are currently three known sites in Delaware, all in Sussex Co.: (1) Nanticoke Wildlife Area, hundreds of plants were observed in 1992 growing on hummocks in a white cedar-red maple-black gum swamp, discovered in 1990 by F. Hirst; (2) Great Cypress Swamp, hundreds of plants were observed growing in a poorly drained loblolly pine woods by B. McAvoy in 1992; and (3) Nanticoke River near Middleford, a small population of approximately 30 plants was observed growing on hummocks in an Atlantic white cedar-red maple swamp by K. Clancy & B. McAvoy in 1992.

Lobelia elongata Small, elongated lobelia. Tatnall (1946), who cited collections by Commons (1877, 1880) from "ponds, Millsboro," and a 1907 record from Brown collected along "Indian River, Millsboro," considered this species to be "rare, in wet places of the Coastal Plain." Tucker et al. (1979) reported that it was last seen in Delaware in 1907. Today this *Lobelia* is known from two extant Sussex Co. sites: (1) along Guinea Creek, less than 10 plants were observed above brackish marsh in a freshwater seepage habitat by C. Ludwig & B. McAvoy in 1992; and (2) Upper Love Creek near Rt 24, an abundant flowering and fruiting population was observed in fresh-tidal marsh on both sides of the creek by C. Ludwig & B. McAvoy in 1992. The latter population co-occurs with other rarities including: *Bidens coronata, Eryngium aquaticum, Sabatia dodecandra,* and *Sacciolepis striata.*

Lupinus perennis L., wild lupine. This species was reported by Tatnall (1946) to be "infrequent in sandy soil . . . southern New Castle Co. southward. . . ." However, extensive inventories indicate that this species is much rarer than Tatnall reported. It is currently known from three locations: (1) near Killens Pond State Park, Kent Co., a vigorous flowering population of several hundred stems was observed in sandy soil along a roadside in 1991 (K. Clancy 2210, DNHI Reference Herbarium); and (2) southwestern Sussex Co., in the Nanticoke Wildlife Area, two populations of less than 50 stems and ca. 200 stems, respectively, were observed along roadsides (several miles apart) in dry, sandy pine-oak woods in 1988 by C. Ludwig, and 1989 by F. Hirst.

Malaxis unifolia Michx., green adder's-mouth orchid. Tatnall (1946) listed this species as "infrequent but widespread in both Piedmont and Coastal Plain provinces," while Phillips (1978) stated that it was "infrequent throughout." Currently it is known from three locations: (1) near Sandhill, Sussex Co., less than ten plants were observed in roadside woods by F. Hirst in 1984; (2) south of Ellendale, Sussex Co., one fruiting individual was observed in a rich, mesic woods by F. Hirst in 1989; and (3) near the Cedar Swamp, New Castle Co., about 30 individuals were observed in a wet sweetgum woods in 1992 by J. Ebert & J. Holt.

Matelea carolinensis (Jacq.) Woodson, Carolina angelpod. Tatnall (1946) reported that this species was "infrequent, in thickets, or climbing on fences, in southern New Castle, . . . Kent . . . counties." Brown and Brown (1972) stated that this species was "infrequent in Cecil, Kent, and Queen Anne counties" on Maryland's Eastern Shore. Harvill et al. (1992) did not list it for Virginia's portion of the Delmarva. This plant is known from one location: along the MD-DE state line, about 40 plants were observed at the edge of road and scattered in woods by J. Ebert & J. Holt in 1992. The habitat suggests that it may be more common than currently believed.

Nelumbo lutea (Willd.) Pers., American or yellow lotus. This plant was reported to be "rare" by Tatnall (1946) who cited one locality: St Jones Creek, 2.5 miles below Dover, 1863 (A. Commons s.n., PH), 3 August 1930 (R. R. Tatnall 965, DOV, GH, PH). In addition, several undocumented records were also mentioned by Tatnall; Drawyers Creek below Shallcross Lake; Moore's (Wiggins) Pond, 1 mile nw of Townsend; and the sw end of McGinnis Pond, 2 mile e of Canterbury. Tucker et al. (1979) suggested that it was "probably extirpated." There is currently one known extant site: in Dover south of the Hwy 13 bridge, in tidal marsh along the St. Jones River. This population was brought to the attention of DNHI in December 1990 and a small population was observed in July 1991 (K. Clancy pers. obs.); it may represent what remains of the historical St. Jones' population.

Nymphoides cordata (Ell.) Fern., little floating heart. This species was reported by Tatnall (1946) to be "infrequent, on ponds, from central Kent." It is known from one site: west of Lewes, where less than 100 individuals occur with 13 other state rare species, in a coastal plain pond discovered by F. Hirst in 1988. More field work is needed to accurately assess this species' status in Delaware, as it could easily be confused with the often sympatric, and more common *N. aquatica.*

Panicum hirstii Swallen, Hirst's panic grass, C2. One of the rarest grasses known, this plant occurs in wet meadows or temporary ponds in NJ, DE, NC, and GA (A. Weakley pers. comm., Kral 1983). *P. hirstii* is known from one Sussex Co. location: Assawoman Bay Wildlife Area, a small population, varying from 10 to several hundred culms, occurs in a coastal plain pond (Delmarva Bay) within a pine-hardwood forest, discovered by F. Hirst in 1984.

Passiflora lutea L., yellow passion-flower. Tatnall (1946) stated that *P. lutea* was "local . . ." and cited collections from only the Maryland and Virginia portions of the Delmarva. However, a check of herbaria uncovered two historical collections: (1) "Delaware" 1824? (Nuttall?, GH); and (2) "Delaware" 1833 (H. C. Beyrich, MO). There are currently two known populations (Clancy 1993): (1) near Dover and the St. Jones River, Kent Co., several flowering vines at the edge and several dozen seedlings just inside a narrow second-growth mixed deciduous forest, discovered in 1991 (K. Clancy 2315, DNHI Reference Herbarium, PH); and (2) near Lewes, Sussex Co., an extensive flowering and fruiting population was observed in a clearing of a mixed oak-pine forest in 1991 (K. Clancy 2381, DNHI Reference Herbarium, PH).

Pellaea atropurpurea (L.) Link, purple cliff-brake. This fern was not reported by Tatnall (1946) for the Delmarva. It is currently known from two locations on the Piedmont: (1) near Rockland, about 100 plants were observed growing on a stone wall above the Brandywine Creek, (Ebert et al. 1990); and, (2) along Rockland Road, approximately 100 plants were observed, also growing on a stone wall, discovered in 1990 by J. Ebert & J.

Holt. These are the first known sites for this species in Delaware, and perhaps in the Delmarva.

Platanthera peramoena (Gray) Gray, purple fringeless orchid. Tatnall (1946) reported this species to be "rare and local . . ." and cited several historical collections from New Castle Co.: (1) moist meadows above Rockland along Brandywine Creek, 8 Aug 1864 (A. Commons s.n., PH); (2) Granogue, (Canby, no date); (3) meadow along White Clay Creek, "rather abundant at this station," ca. 1 mile north of Newark, 4 Aug 1944 (G. R. Proctor 1113 pers. herb.) and 28 Jul 1945 (R. R. Tatnall 5222, DOV, PH). There is currently one known extant population, which may be a relocation of the 1944 Proctor and/or the 1945 Tatnall sites: White Clay Creek drainage near Newark, between 1988–91, a small population, ranging from 1–6 individuals, was observed in an open wet meadow at the edge of floodplain woods, no plants were observed in 1992, this population was discovered by C. Pattison (see Ebert et al. 1990).

Polypodium polypodioides (L.) Watt, resurrection fern. Tatnall (1946) reported this species to be "infrequent . . . from Sussex Co. to . . . Accomac Co." It is currently known from one site: near Laurel, a small population of a few vigorous, spore-producing individuals, was observed on a tree in 1979 (R. Radis pers. comm.). Field surveys are needed to determine the current status of this species.

Rhexia aristosa Britt., awned-meadowbeauty, C2. Tatnall (1946) considered this plant to be "rare and local . . .," and cited several historical collections: (1) Ellendale, 24 Jul 1893 (Canby s.n., DOV), and several later collections; and (2) at Wilmington, "south side of Christina Creek," 21 Sep 1896 (Commons, s.n., PH). *R. aristosa* is currently known to be extant from six Sussex Co. sites: (1) Ellendale wet meadow, less than 50 plants were observed growing in a ditch, it has been monitored at this locality since 1984; (2) Assawoman Bay Wildlife Area, in a woodland pond (Delmarva Bay) with other rare species (*Coelorachis rugosa, Panicum hirstii,* and *Sclerolepis uniflora*), population numbers have fluctuated dramatically over the years (1984–1992), discovered by F. Hirst in 1984; (3) south of Ellendale, between 1988 and 1992 four separate populations have been located, in ditches in sandy, open pine plantation, ca. 5000 plants were observed in 1991, but fewer than 100 in 1992; in a clear-cut, ca. 3000 plants in 1991 and 1992; at the edge of an excavated pond, three plants in flower; and in a ditch, five flowering individuals, discovered by F. Hirst, R. Wilson, and B. McAvoy. The latter four sites, contain an assemblage of state rare species (*Amphicarpum purshii, Boltonia asteroides, Eleocharis robbinsii, Fuirena pumila, F. squarrosa, Hypericum adpressum, H. denticulatum, Lobelia canbyi, Rhynchopsora fusca, R. gracilenta, R. torreyena, Scleria reticularis.*) Since all but one of the sites occur in degraded habitats and because the awned-meadow beauty is a candidate for federal listing, the species has been ranked S1.

Sagittaria calycina Engelm., Mississippi arrow-head. Tatnall (1946) reported that this species "infrequent in ditches, and tidal mud of Delaware River, in New Castle Co., where not recently collected. . . ." There are currently four known extant sites: (1) Along the Delaware River near the Delaware Memorial Bridge, more than 100 plants were observed at the upper-edge of the inter-tidal zone in 1990 by A. E. Schuyler; (2) near New Castle, along the Delaware River, more than one hundred seedlings were observed in tidal mud growing with typical marsh species such as *Amaranthus cannabinus, Bidens laevis, Echinochloa walteri, Impatiens capensis, Scirpus pungens, S. tabernaemontanii,* and *Spartina alterniflora* in 1992 (K. Clancy 2551, with A. E. Schuyler, DNHI Reference Herbarium); (3) Blackbird Creek, near Blackbird Landing, numerous plants were observed in mud at edge of freshtidal marsh in 1990 by F. Hirst & R. Wilson; and (4) Drawyers Creek, near DuPont

Hwy, abundant in exposed mud of brackish tidal marsh (K. Clancy 2661, DNHI Reference Herbarium).

Sagittaria teres Wats., slender arrowhead. This species was reported by Tatnall (1946) as "rare." One Delaware collection was cited by Tatnall and later by Tucker et al. (1979): "Millpond at Milton, (Commons, 17 Aug 1899, PH)." The site of Common's collection was likely Wagamons Millpond, where *S. teres* has been unsuccessfully searched for during the past 10 years. Presently there is one known site: Reynolds Millpond, north of Milton, where one plant was noted in 1988 by C. Ludwig. Subsequent searches in 1990 and 1992 failed to relocate this plant (B. McAvoy pers. comm.).

Sanicula marilandica L., black snakeroot. This species was described by Tatnall (1946) as "rare" on the Delmarva and was known from several historical collections: (1) near Wilmington, 1896, (W. M. Canby s.n., DOV); (2) near Centreville, 1878, 1898, (A. Commons s.n., PH); (3) Choptank Mills, 1904, (Stone s.n., PH); and (4) Arden, New Castle County, in open woods, 1945, (Morris & D. Berd 17514, NY). The latter collection was cited by Moldenke (1945). There is currently one known extant site: five plants were observed along Snuff Mill Road near the PA state line by J. Ebert & J. Holt in 1992.

Sanicula trifoliata Bickn., long-fruited snakeroot. This species was not reported by Tatnall (1946). Brown and Brown (1984) considered this species to be "scarce" and listed Harford Co. and Baltimore City for its distribution in MD. Harvill et al. (1992) do not list this species in the Virginia portion of the Delmarva. The one known locality occurs along a roadside, se of Hoopes Reservoir, where less than 50 mature fruiting plants were observed in 1989 (Ebert et al. 1990).

Schizaea pusilla Pursh, curly grass fern. This diminutive fern was recently discovered near Milton where a vigorous population was observed on hummocks and downed logs in an Atlantic white cedar swamp by F. Hirst & R. Wilson (Hirst 1990). Subsequent surveys have shown it to be more abundant at this site than previously reported (Hirst pers. comm.).

Scirpus etuberculatus (Steudel) Kuntze, Canby's bulrush. According to Tatnall (1946), Canby's bulrush was "rare . . . reaches the northern limit of its range in Sussex Co." It is known from two historical sites: (1) ". . . ponds, rare," 5 Aug 1874, (A. Commons s.n., PH); and (2) Ellis pond, 4.75 mile s of Laurel, 9 Aug 1961 (F. Hirst 59, PH). Surveys between 1989 and 1992 failed to relocate this population, Ellis Pond is in the latter stages of succession to a shrub swamp and very little open water remains. Canby's bulrush may have last been seen at the site in 1972 (A. E. Schuyler pers. comm.). There is currently one known extant population: Raccoon Pond, several thousand plants were observed growing in shallow water by C. Ludwig in 1988; surveys in 1990 revealed the presence of only a few, scattered clumps.

Sclerolepis uniflora (Walter) BSP, pink bog-button. Tatnall (1946) cited one New Castle Co. location for this species: "Sassafras Crossroads" (=Green Springs Station), 1866, (A. Commons s.n., DOV, PH)." In Delaware, it usually co-occurs with *Boltonia asteroides* and *Coreopsis rosea*. Recent surveys by Natural Heritage botanists have resulted in its discovery at five Sussex Co. sites: (1) Assawoman Bay Wildlife Area, two populations occur in woodland ponds (Delmarva Bays), one has remained relatively stable between 1984 and 1992 forming dense patches, while the other has declined; (2) between Ellendale and Robbins, less than 100 mature plants were observed in wet spots of a recently re-planted pine plantation in 1988 by F. Hirst; (3) Ellendale Wet Meadow, a small population of ca. 50 plants was observed in 1991 after being re-discovered by F. Hirst in 1984; and (4) near Georgetown, several hundred plants were observed in wet deciduous woods by F. Hirst &

R. Wilson in 1992. In addition to the presence of *Sclerolepis,* site 4 is also home to the rare *Coelorachis rugosa, Eupatorium leucolepis, Hypericum dentatum, Lobelia canbyi, Polygala cruciata, Rhynchospora fusca,* and *Scleria reticularis,* to name a few.

Senecio anonymus A. Wood, Small's ragwort. This species was considered by Tatnall (1946) to be "infrequent" on the Delmarva. Currently it is known from one site: northeast of Mt Cuba, near Owls Nest Road, a relatively large population (more than 100 individuals) growing in a mowed lawn underlain by serpentinite was discovered in 1992 by J. Ebert, J. Holt, & B. McAvoy.

HISTORICAL SPECIES

Selected SH or SX ranked species are discussed below. These species have not been seen or collected in Delaware for at least 15 years. Taxa classified SX have been searched for repeatedly at all known historical sites and in all potential habitats. In contrast, although taxa ranked SH have not been seen or collected for many years, there appears to be potential habitat yet to survey. In many cases, these species were also believed to be historical, or extirpated, by Tatnall (1946) and Tucker et al. (1979).

Adlumia fungosa (Ait.) Green ex BSP., climbing fumitory, SX. Tatnall (1946) stated that this species was "infrequent" in Delaware, while Tucker et al. (1979) thought that it was "probably extirpated. . . ." Apparently it was never abundant in the state and was restricted to the rocky banks of the Brandywine Creek: (1) opposite Bancroft's Factory, 15 Jun 1869 (A. Commons, s.n., PH); and (2) rocky woods at Wills Rocks, below the High Bridge, 8 Jul 1865, 11 Aug 1897 (A. Commons, s.n., PH).

Aeschynomene virginica (L.) BSP., sensitive joint-vetch, LT, SH. According to Tatnall (1946) this species was "formerly frequent on tidal shores of the Delaware River, from Holly Oak to Delaware City." Tucker et al. (1979) considered the species to be "definitely extirpated." Historical localities all occur in New Castle Co.: (1) river shores, near Wilmington, Aug 1878 (W. M. Canby s.n., NY); (2) Holly Oak, 23 Aug 1888 (J. B. Brinton s.n., NY); and (3) tidewater along Brandywine-Christina Rivers, 1846 (B. Hoopes 486, NY). Although much of Delaware's tidal habitat has been degraded, areas requiring more thorough surveys include the Christina, Appoquinimink, and Nanticoke Rivers and Drawyers Creek.

Amaranthus pumilus Raf., seabeach pigweed, PT, SH. The sea-beach amaranth is extirpated from most of the northern half of its range south to Virginia, although it has reappeared in New York, possibly as a result of severe storms in 1990 that may have transported propagules from the Carolinas (S. Young pers. comm.), or unearthed a seed bank (A. Weakley pers. comm.). It was reported by Tatnall (1946) to be "rare, on sea beaches; southeastern Sussex Co.," with a single, documented collection: Baltimore Hundred (area from the Indian River Inlet south to state line), 10 Sep 1875 (A. Commons s.n., PH). A winter storm that battered Delaware's coastal beaches in January 1992 brought some hope of its reappearance in the state, but surveys of the beaches from Cape Henlopen to Fenwick Island in the summer of 1992 failed to relocate this plant.

Arabis drummondii A. Gray, Drummond rock-cress, SH. Tatnall (1946) cited one Delmarva collection: Concord Station, Wilmington, Jun 1897 (A. Commons, s.n., PH).

Arethusa bulbosa L., dragon's-mouth, SH. Tatnall (1946) stated that this distinctive orchid was "rare and local" and Tucker et al. (1979) believed it "definitely extirpated." Historical locations include: (1) Farnhurst, McCrones Swamp (now State Hospital), New Castle Co., 30 May, 2 Jun 1866, 30 May 1882 (A. Commons s.n., PH), and 5 May 1866, 30 May 1882 (W. M. Canby s.n., PH); (2) Millsboro, Sussex Co., sandy swamp, 23 May 1876

(A. Commons s.n., PH); (3) Milford, 5 miles south at margin of Clendaniel Pond (Hudson Pond?), Sussex Co., 30 May 1928, 11 May 1929, 30 May 1930 (R. R. Tatnall, DOV, PENN); and (4) near Dagsboro, Sussex Co., Jun 1809 (T. Nuttall s.n., PH).

Arnica acaulis (Walter) BSP, leopard's-bane, SH. Tatnall (1946) listed this species as "infrequent; sandy woods and roadsides on the coastal plain . . .," while Tucker et al. (1979) thought that it was extirpated from the state. Historical collections, all from New Castle Co., include: (1) "New Castle Co." Jul 1862 (W. M. Canby s.n., PH); (2) Townsend, 30 May 1890 (J. B. Brinton s.n.), and sandy woods, 11 Jun 1890 (A. Commons s.n., PH); (3) 4.0 mile south of Odessa, DuPont Hwy, meadow, 19 Jun 1933 (H. E. Stone s.n., PH); (4) 5.0 mile south of Odessa, open grass roadside, DuPont Hwy, 0.25 mile south of Union Church, 3 Jun 1934 (R. R. Tatnall s.n., PH), and border of low woods, near Union Church, ca. 1.0 mile northwest of Blackbird, 15 Jun 1937 (B. Long 50096, 50097, PH).

Asclepias longifolia Michx., long-leaf milkweed, SH. This species was last collected in 1934 and according to Tatnall (1946) was "very rare . . . now apparently extinct in our area." Tucker et al. (1979) considered it to be "definitely extirpated." It was known from one location: Ellendale, in ditches along the railroad, south of the village (DOV, GH, PH).

Asclepias quadrifolia Jacq., whorled milkweed, SH. Tatnall (1946) considered this distinctive milkweed "infrequent, in dry hilly woods of the Piedmont; rare on the Coastal Plain . . .," while Tucker et al. (1979) believed that it had been extirpated. Historical collections include: (1) near Centreville, dry woods, Jun 1865 (A. Commons, s.n., PH); (2) Mt. Cuba, 3 Jun 1894 (J. B. Brinton, s.n., PH) and 30 May 1895 (I. A. Keller, s.n., PH); and (3) below Yorklyn along the Red Clay Creek, loamy wooded slope, 24 May 1924 (B. Long 30251, PH).

Asplenium rhizophyllum L., walking fern, SH. According to Tatnall (1946) this plant was "rare, on wooded rocky slopes of the Piedmont." Tucker et al. (1979) considered it to be "definitely extirpated." Historical collections include: (1) Mt. Cuba, Jul 1865 (A. Commons, s.n., PH); near foot of rocky slope, just above deep railway cut, 0.5 mile north of Mt. Cuba 27 Jun 1931 and 17 April 1942 (R. R. Tatnall 1195, 5004 DOV); (2) near Centreville, 13 Jun 1877 (A. Commons, s.n., PH); (3) White Clay Creek Valley, reported by Linehan et al. 1970 (cited in Fleming 1978); and (4) high up the rocky slope, along east side of Brandywine Creek above Rockland, 24 Mar 1929 (R. R. Tatnall 232, DOV).

Carex bicknellii Britton, Bicknell sedge, SX. This sedge was known from a single Delaware location: near Centreville, on serpentine barren, dry soil, 26 May 1863 (A. Commons, PH).

Carex polymorpha Muhl., variable sedge, C2, SH. Tatnall (1946) stated there was one known collection of this species on the Delmarva (Cecil Co., MD). Apparently he overlooked the only known Delaware collection: "Sussex Co.," 1874 (W. M. Canby s.n., DOV). Because this sedge grows in xeric to mesic woods, it is hoped that it will yet be relocated in the state.

Carex striatula Michx., lined sedge, SH. Tatnall (1946) considered the species to be "rare; wooded banks, Piedmont and Coastal Plain. . . ." Historical locations include the following: (1) Mt. Cuba, rocky woods, 26 May 1884, 19 Jun 1895 (A. Commons s.n., PH), and 4 Jul 1903 (W. Stone s.n., PH); (2) Greenbank, woods, 27 May 1879 (A. Commons s.n., PH); (3) 1.5 mile north of Choate, road bank, edge of woods along Pike Creek, 18 May 1940 (R. R. Tatnall 4495, DOV, PH); and (4) Wilmington, May 1893 (W. M. Canby s.n., DOV).

Chamaedaphne calyculata (L.) Moench., leatherleaf, SH. Tatnall (1946) stated that leatherleaf was ". . . not recently found within our limits, in spite of careful search."

Tucker et al. (1979) considered it "definitely extirpated." Historical locations: (1) Thompson's Swamp, 1.5 mile northwest of New Castle, 1858 (W. M. Canby s.n., DOV); (2) Frankford, 1875 (A. Commons s.n., PH); and (3) Townsend, sandy swamps, 11 Jun 1890 (A. Commons s.n., PH).

Cheilanthes lanosa (Michx.) D. C. Eat., hairy lip-fern, SX. Tatnall (1946) reported that this species was "rare, on rocky hills . . . in and near Wilmington, where now extinct." Tucker et al. (1979) considered the hairy lip-fern to be "definitely extirpated." Historical collections include: (1) near Wilmington, 1861 (I. Hoopes, s.n., PH); (2) Wilmington, east side of Brandywine Creek below Jessup's papermill (site now destroyed), rocky ridge, 13 Sep 1864 (A. Commons, s.n., PH); and (3) Wilmington, banks of Brandywine opposite Bancroft's Factory, on rocks, 3 Dec 1889 (A. Commons, s.n., PH). All three of the above collections may have been made at the same location. As shale outcrops, the habitat that typically supports this species, are lacking in Delaware, it is doubtful that this fern will be relocated.

Cicuta bulbifera L., bulb-bearing water hemlock, SX. Although Tatnall (1946) did not specifically comment on the abundance or rarity of this species, Tucker et al. (1979) thought that it was "definitely extirpated." There is one historical site: New Castle Co., wet ground at top of north bank of C & D Canal, west of Summit Bridge, 24 Aug 1869 (A. Commons, s.n., PH).

Cleistes divaricata (L.) Ames, spreading pogonia, SH. Tatnall (1946) considered this species "rare" and Tucker et al. (1979) thought it "probably extirpated." Historical collections, all in Sussex Co. include: (1) meadow and thicket-pasture east of Ellendale, 22 Jul 1908 (B. Long s.n., PH), and 7 Sep 1938, 12 Jun 1939 (A. V. Smith & R. R. Tatnall s.n., DOV); (2) 3 miles northwest of Rehoboth, in ditch along railroad, 4 Jul 1930, 5 Sep 1936 (R. R. Tatnall s.n., DOV); and (3) near Dagsboro, Jun 1809 (T. Nuttall s.n., PH).

Crassula aquatica (L.) Schonl., pygmy-weed, SX. Tatnall (1946) stated that this species was "rare, on muddy shores . . ." and listed one historical site: Brandywine Creek above railroad bridge, collected by Canby in 1867, but no specimen was seen. Ferren and Schuyler (1980) stated that it "has not been collected in the Delaware system for over 50 years."

Cyperus plukenetii Fern., a flatsedge, SX. Tatnall (1946) considered this species to be "rare, in dry ground. . . ." Historical localities include: (1) Rehoboth, Sussex County, 13 Aug 1896 (A. Commons s.n., PH); (2) Millsboro, 21 Sep 1907 (S. Brown, PH); and (3) Wilmington, Giant's Cave, on Brandywine, 28 Jul 1866 (A. Commons s.n., PH).

Cyperus tenuifolius (Stuedel) Dandy, thinleaf flatsedge, SH. Tatnall (1946) cited one known collection from the Delmarva: "moist soil," Baltimore Hundred (Sussex Co., south of Indian River Inlet), 10 Sep 1875 (A. Commons s.n., PH).

Desmodium humifusum (Muhl.) Beck, spreading tick-clover, C2, SH. Tatnall (1946) reported the species to be "rare, in sandy soil." Historical collections, all in New Castle Co., include: (1) sandy woods near Collins Beach, 27 Aug 1867 (A. Commons s.n., NY); (2) wooded hillside of Red Clay Creek, near Delaware Western RR tank, Sep 1879 and 1 Oct 1879 (W. M. Canby s.n., NY); (3) cedar swamp, 9 Aug 1866 (A. Commons s.n., NY); and (4) New Castle City, rare, 27 Aug 1867 (A. Commons s.n., NY). Considering that it is known to occur in disturbed habitats (i.e. along powerline clearings) it may yet be relocated in Delaware.

Eriophorum gracile Koch ex Roth, slender cotton-grass, SX. This species was thought to be "rare . . ." in Delaware (Tatnall 1946). Historical locations include: (1) Thompson's swamp, 1.5 miles northeast of New Castle (E. Tatnall, 1858, DOV); (2) McCrone's swamp, near Farnhurst, 20 Jun 1876 (A. Commons s.n., PH); and (3) in sphagnum, east of VanDyke, 7 Jun 1881 (A. Commons, s.n., PH). The State Hospital now occupies the former McCrone's swamp site, and Thompson's swamp has been destroyed (or severely degraded) due to expansion of Wilmington and New Castle. The best area for relocating this species is the wetlands near Vandyke.

Eupatorium resinosum Torr., pine barrens boneset, C2, SH. Tatnall (1946) considered the pine-barrens boneset to be "rare, in low pine barrens . . .," while Tucker et al. (1979) stated that this species was "definitely extirpated." There are two historical sites: (1) in low pine barrens near Gumboro, 5 Aug 1874 (A. Commons, s.n., PH); and (2) Baltimore Hundred (south of Indian River Inlet), 10 Sep 1875 (A. Commons, s.n., PH).

Euphorbia purpurea (Raf.) Fern., Darlington's or glade spurge, C2, SH. Tatnall (1946) stated that it was "rare, in the Piedmont Province," while Tucker et al. (1979) considered it to be "definitely extirpated." There is one known historical location: swamp west of Hockessin, 8 Jun 1881 (A. Commons s.n., PH). This site is in the northwest part of the state within 10 km of an extant PA population (Pennsylvania Natural Diversity Inventory pers. comm.).

Fimbristylis annua (All.) Roemer & Schultes, annual fimbry, SX. Tatnall (1946) stated that the annual fimbry was "rare, known from serpentine soil of New Castle Co., . . . no recent collections." Tucker et al. (1979) thought that it was "possibly extirpated." Historical location: near Centreville, New Castle Co., moist soil (serpentine barrens), Sep 1972 (A. Commons s.n., PH).

Gentiana autumnalis L., pine barren gentian, SH. Tatnall (1946) cited one historical location: Sussex Co., pine barrens, 10 Sep 1875 (A. Commons, s.n., PH). Botanists should continue to search for this species in the moist pinewoods of southern Delaware.

Gentianopsis crinita (Froelich) Ma., fringed gentian, SH. Tatnall (1946) reported this species "rare, New Castle Co. . . . now extinct in most or all of the above localities." Tucker et al. (1979) reported that it was "definitely extirpated." Collections include: (1) near Centreville, 1865, 1878 (A. Commons s.n., PH); (2) Faulkland, 24 Sep 1886 (R. R. Tatnall s.n., DOV); (3) Southwood, Oct 1894 (W. M. Canby, DOV); (4) Brandywine Springs, 8 Oct 1896 (W. M. Canby, DOV); and (5) roadside bank one mile west of Centreville, 12 Oct 1928 (R. R. Tatnall 221, DOV, PENN).

Hydrangea arborescens L., American hydrangea, SX. Tatnall (1946) reported that this species was ". . . rare in New Castle Co." It was known from one site: Mt. Cuba, 13 May 1892 (J. Crawford s.n., PH).

Lobelia boykinii T. & G., Boykin's lobelia, C2, SH. Tatnall (1946) considered the species "rare; meadows and ditches . . .," and Tucker et al. (1979) reported it "probably extirpated." It was known from one location: Ellendale, 24 Jul 1893 (W. M. Canby, s.n. DOV); ditches along RR, 9 Jul 1908, 20 Jun 1909 (C. S. Williamson, s.n., PH), and 6 Jul 1913 (Long & Bartram PH).

Lophiola aurea Ker Gawler (=*L. americana* (Pursh) Wood), gold-crest, SH. This species was cited by Tatnall (1946) as "very rare. . . ." There is one historical site: Sussex Co., pine-barren bogs between Gumboro and Laurel, 5 Aug 1874 (A. Commons, s.n., PH).

Lygodium palmatum (Bernh.) Sw., climbing fern, SH. This distinctive fern was known from two historical collections in New Castle Co., and more recently, from southwestern Sussex Co.: (1) border of wooded swamp ca. 1 mile north of streamlet tributary to Christina Creek, 22 Apr 1933 (B. Long s.n., CHRB); (2) woods along bank above Christina Creek 1.25 miles wnw of Bear Station (A. W. Leeds s.n., CHRB); and (3) low woods near Woodland Ferry (discovered by R. Radis in 1976, pers. comm.). The two New Castle collections may represent the same locality reported by Tatnall (1946). The Sussex Co. site needs to be revisited to determine the current status of this plant.

Menyanthes trifoliata L., buckbean, SX. Tatnall (1946) stated that the species was "formerly rare in swamps of New Castle Co. . . . now probably extinct in our area." Tucker et al. (1979) thought it "probably extirpated." It was known from two locations: (1) Thompson's Swamp, nw of New Castle, 1840 (E. Tatnall s.n., DOV); and (2) Cedar Swamp, 1866 (Tatnall 1946). Thompson's Swamp has been virtually destroyed, but the Cedar Swamp area still has extensive "intact" habitat.

Micranthemum micranthemoides (Nutt.) Wettst., Nuttall's micranthemum, C1*, SX. This species is presumed to be extinct and has not been seen anywhere since 1941 (The Nature Conservancy 1987). According to Tatnall (1946) it was "infrequent . . . in New Castle Co.," and was known to occur "near Claymont, Delaware River between tides," 3 Oct 1866 (A. Commons s.n., DOV).

Monotropsis odorata Elliott, sweet pinesap, SH. Tatnall (1946) did not mention the species as occurring on the Delmarva. In Maryland it is known from Anne Arundel and Baltimore counties (G. Cooley pers. comm, Brown and Brown 1984). Apparently, there were two Delaware collections: (1) "Delaware," no date (E. Durand s.n. US 968638); and (2) "Delaware," no date (E. Durand s.n., PH). These may have been made in the 1860s, since Durand is known to have collected *M. odorata* in Maryland in 1867.

Muhlenbergia torreyana (Schultes) A. Hitchc., Torrey's dropseed, SH. This grass was considered "rare" by Tatnall (1946), while Tucker et al. (1979) thought it "definitely extirpated. . . ." Historical sites: (1) Felton, Kent Co. 25 Sep 1873, 25 Sep 1875 (A. Commons, s.n., NY, PH, US); and (2) bogs 0.5 mile east of Ellendale at RD 231, Sussex Co., Sep 1875 (W. M. Canby, s.n., NY); 27 Sep 1895 (A. Commons, s.n., PH); 12 Oct 1940 (A. Chase 12619, US); and also 12 Oct 1940 (R. R. Tatnall 4473, GH).

Narthecium americanum Hudson, bog-asphodel, C1, SX. Tatnall (1946) believed the species "rare . . ." while Tucker et al. (1979) stated that it was "definitely extirpated." Historical locations include: (1) swamp near Lewes, Sussex Co., 1 Aug 1895 (A. Commons s.n., PH); and (2) damp railroad bank at Vandyke, New Castle Co., 26 Sep 1894 (Tatnall 1946).

Ophioglossum vulgatum L. var. *pseudopodum* (Blake) Fawr., northern adder's tongue, SH. Tatnall (1946) considered this fern to be "rare," while Tucker et al. (1979) state that this species is "definitely extirpated." Historically, it is known from one New Castle Co. locale: near Centreville, moist place in woods, 14 Jul 1873 (A. Commons s.n., PH).

Oxypolis canbyi (Coult & Rose) Fern., Canby's dropwort, LE, SH. This plant was last collected in Delaware in 1894. The historical site, the type locality, was the meadows and bogs at Ellendale. According to Dill and Tucker (1986) a total of seven field trips to the site from 1867 to 1894 produced 23 herbarium sheets. Its recent discovery in Maryland (Boone et al. 1984) has renewed hope that *O. canbyi* will be rediscovered in Delaware.

Polygala paucifolia Willd., gay-wing mikwort, SX. Tatnall (1946) considered this plant "very rare, in the Piedmont of New Castle Co. . . .," while Tucker et al. (1979) thought it "possibly extirpated." It was known from a single locality: 0.25 mile north of Mt. Cuba Station, on railroad bank, May 1890 (W. Tatnall, Jr. s.n., DOV) and many later collections deposited at DOV, PENN, PH, and US.

Polygala senega L., seneca snakeroot, SX. Tatnall (1946) stated of this species "formerly rather frequent in rocky woods of the Piedmont, now rare or perhaps extinct in our range." Tucker et al. (1979) also thought *P. senega* extirpated. Historical collections include: (1) Wilmington, May 1890, (W. M. Canby, s.n., PH); (2) Mt. Cuba, rocky woods, 15 & 21 Jun

1865, 27 May 1873 (A. Commons, s.n., PH); and (3) Guyencourt, south of P. & R. Station, tributary of Brandywine Creek, loamy wooded slopes, 23 Jun 1923 (B. Long 27524) and 1 Jun 1924 (H. Williams, s.n. PH).

Rhynchospora knieskernii Carey, Knieskern's beakrush, LT, SH. This species is only known from Delaware and New Jersey (US Fish and Wildlife Service 1991b). Both historical localities were in Sussex Co.: (1) swamp near Gumboro, 5 Aug 1874 (A. Commons s.n., PH); and (2) Baltimore Hundred (south of Indian River Inlet), 10 Sep 1875 (A. Commons s.n., PH). Considering that *R. knieskernii* is found along powerline right-of-ways and other disturbed habitats in New Jersey (D. Snyder pers. comm.), there is still hope that it may be relocated in Delaware.

Rhynchospora oligantha A. Gray, few-flowered beakrush, SH. Tatnall (1946) considered this species to be "rare," while Tucker et al. (1979) thought it "possibly extirpated." There are two Sussex Co. collections, perhaps from the same site: (1) bogs, 1.5 mile south of Lewes, Jul 1878 (W. M. Canby s.n., DOV, PH); and (2) near Lewes, 26 Aug 1895 (A. Commons s.n., PH).

Schwalbea americana L., chaffseed, LE, SH. Tatnall (1946) considered the species "rare" and Tucker et al. (1979) stated that it was "definitely extirpated." Collections, all from New Castle Co. include: (1) St. Georges, Jun 1866 (W. M. Canby s.n., NY), along the canal (or south side of canal, below St. Georges), St. Georges, 22 Jul 1875 (A. Commons s.n., NY, PH); and (2) on a hill south side of C & D Canal, 1.0 mile below the crossing of the Delaware Railroad, Jun–Aug 1862 (W. M. Canby s.n., NY). Most of the habitat in this area has been destroyed or degraded during the past 100 years and there is little hope that the chaffseed will be relocated.

Scutellaria saxatalis Riddell, rock-skullcap, C2, SH. Tatnall (1946) reported the species to be "rare, in rocky woods" and Tucker et al. (1979) thought it "probably extirpated." Historical sites were in New Castle Co.: (1) stony places above Rockford, 10 Jun 1836 (E. Tatnall s.n., PH); (2) Brandywine, 1888 (W. Tatnall s.n., PH); and (3) Wilmington, rocky woods, 19 Jun 1897 (A. Commons s.n., PH).

Solidago uliginosa Nutt., bog-goldenrod, SH. Tatnall (1946) stated that this species was "infrequent, in bogs, Coastal Plain, New Castle, Sussex, . . . counties," and Tucker et al. (1979) thought it was extirpated. All of Delaware's collections were from New Castle Co.: (1) swamps, New Castle, no date (W. M. Canby s.n.); (2) McCrone's swamps, near Wilmington, 10 Oct 1876 (A. Commons s.n.); (3) Wilmington, 10 Sep 1890 (A. Commons s.n.); (4) Pencader Hundred, Porter's Station, in dry soil, 9 Oct 1890 (A. Commons s.n.); (5) Kiamensi, swamps, 8 Aug 1894 (A. Commons s.n.); (6) swamps, near Townsend, 21 Sep 1894 and 9 Oct 1896 (A. Commons s.n.); and (7) swampy margins of woods, southwest of Vandyke, 9 Oct 1908 (B. Long s.n.), all collections at PH.

Tofieldia racemosa (Walter) BSP, coastal false-asphodel, SH. This species was reported by Tatnall (1946) to be "rare, in wet ground or shallow water . . .," while Tucker et al. (1979) considered it "probably extirpated." Historical collections may all refer to the same locality: (1) "Glades south of Leweston," and swamp 1.0 mile south of Lewes, Sussex Co., 13 Jul, 22 Jul 1878 (W. M. Canby s.n., PH, NY); (2) near Lewes, 15 Aug 1895 (A. Commons s.n., PH); (3) three miles northwest of Rehoboth, 14 Aug 1923 (Otis s.n. GH, PH), 5 Sep 1936, and 5 Aug 1937 (R. R. Tatnall 3173, 3461, DOV, GH); and (4) wet ground on east side of railroad, 0.75 mile northwest of Howlands Glade bridge (Otis s.n., GH, PH).

Triphora trianthophora (Swartz) Rydb., three-birds orchid, SH. This species has not been collected in Delaware since before 1900 (Tucker et al. 1979). Tatnall (1946) considered it "rare and local; meadows and low woods of the Piedmont." The one historical collection was from Hockessin, rich woods, no date (Tatnall 1946).

Xerophyllum asphodeloides (L.) Nutt., turkeybeard, SH. This species was known from one historical site: dry pine woods near Laurel, Sussex Co., 5 Aug 1874 (A. Commons s.n., PH).

ACKNOWLEDGEMENTS

I would like to extend my sincere appreciation to all who have contributed to this paper and to furthering our knowledge of Delaware's rare plants, particularly those individuals who have carried out rare plant surveys: J. Ebert, J. Holt, F. Hirst, C. Ludwig, B. McAvoy, R. Radis, T. Rawinski, W. Rittenhouse, and A. E. Schuyler. A special thanks are also due to B. McAvoy and D. Rothstein for their encouragement and support during the writing of this paper. Thanks go to B. McAvoy and A. E. Schuyler for reviewing previous drafts of this manuscript. Finally, I would like to thank the curators of CHRB, GH, NY, PENN, PH, and US for providing access to their collections.

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ISSN 0198-7356

BARTONIA

JOURNAL OF THE
PHILADELPHIA BOTANICAL CLUB

No. 58

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PUBLISHED BY THE CLUB
ACADEMY OF NATURAL SCIENCES, 1900 BENJAMIN FRANKLIN PARKWAY
PHILADELPHIA, PENNSYLVANIA 19103-1195

Issued 28 June 1994

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Satellite Remote Sensing of Pinelands Ecosystems

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Satellite remote sensing has found increasing application to the investigation of ecological systems at landscape and regional global scales. The synoptic and repetitive nature of satellite remote sensing provides a consistent data set to monitor the earth's surface at different spatial scales and at different temporal frequencies. Passive remote sensing systems measure reflected or emitted energy in the visible, near, middle and thermal infrared (IR) wavelength regions of the electromagnetic spectrum. Each of these different wavelength regions provides different information as to the state of the Earth's surface.

In forested regions, as in the case of the Pinelands, the observed remotely sensed signal is largely determined by the state of the forest overstory vegetation: the community type; the density/biomass; and the leaf area (Peterson and Running 1989). Other factors also have an influence: the understory vegetation; the background soil/litter reflectance; and the topographic slope and aspect. Remote sensing data provides information on the spatial patterns of the vegetation or ecosystem state; the challenge is to translate the information on pattern into information on process at either the ecosystem or landscape level.

This paper reports on an investigation of the utility of Landsat Thematic Mapper (TM) remote sensing imagery for classifying and mapping the major Pinelands vegetation communities. The objectives of this study were: 1) to gain a better understanding of the factors determining the remotely sensed signal observed for Pinelands vegetation; 2) to classify and map the major forest community types in the Pinelands National Reserve Preservation area as of 1988; and 3) to document spatial patterns in forest vegetation type.

METHODS

This study focussed on the central core of the Pinelands National Reserve Preservation Area (Fig. 1). The image used for this study was acquired by the Landsat-5 TM on 8 August 1988 (Path 14/Row 32; Scene ID Y5162815103X0). The TM sensor has seven bands spanning the visible, near IR, middle IR and thermal IR spectral regions. Bands 1-5 and 7 are acquired at a 30 m ground cell resolution, Band 6 (Thermal IR) is acquired at a coarser 120 m grid cell resolution. It should be noted that the image was acquired during the height of a severe drought period. A subset of cloud-free data of high radiometric quality was extracted for analysis. The study area contained a diversity of forest communities typical of NJ Pinelands conditions (McCormick 1979).

A Geophysical Environmental Research Corporation Mark V spectroradiometer was used to measure the spectral radiance (from 0.4 to 2.5 μm) of clipped pitch pine (*Pinus rigida*) and white cedar (*Chamaecyparis thyoides*) foliage in a laboratory setting. This data was compared to the spectral radiance curves extracted from the Landsat TM imagery subsets of relatively homogeneous pitch pine and white cedar forest stands, as well as additional forest community types.

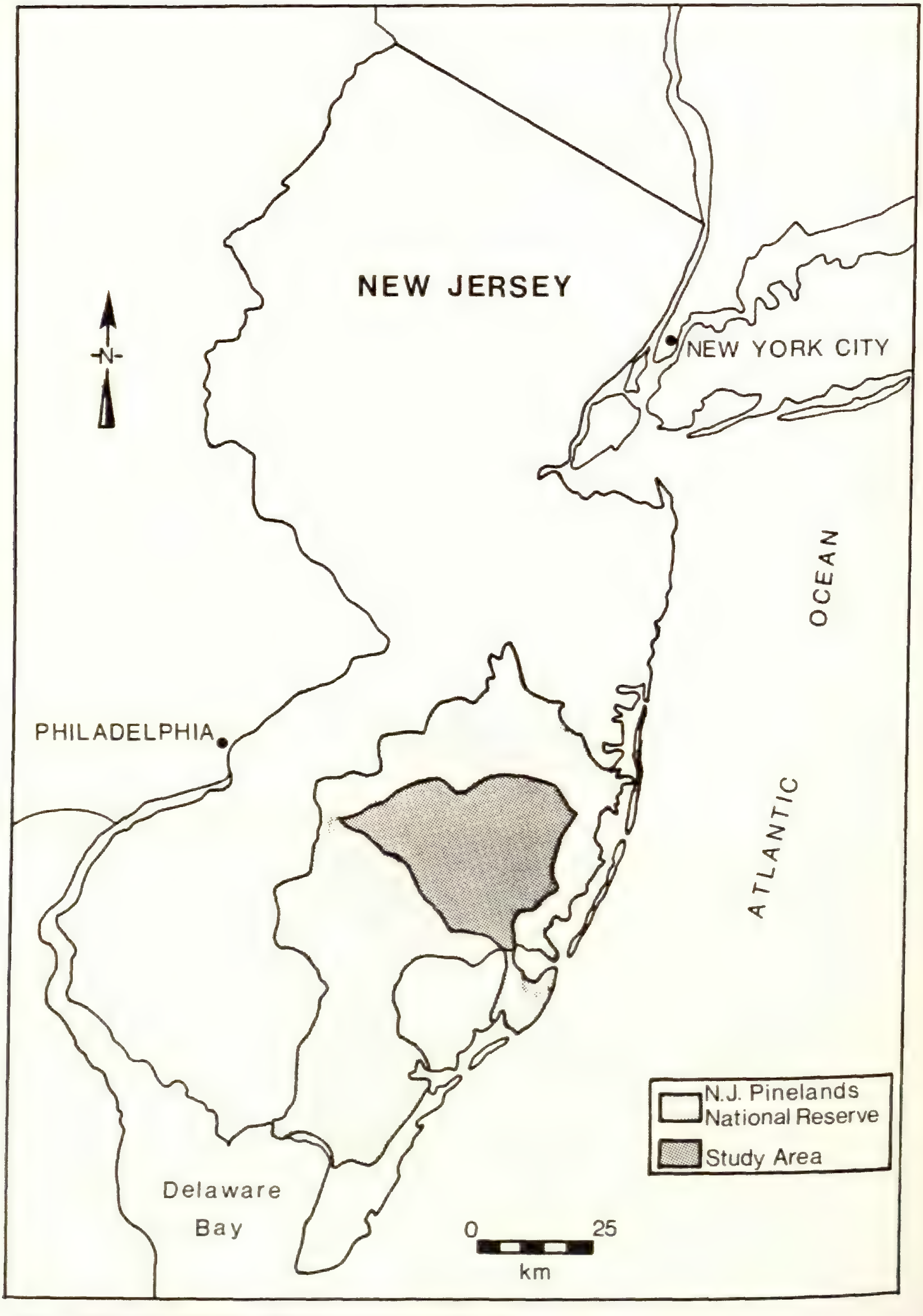
NEW JERSEY
N
NEW YORK CITY
OCEAN
ATLANTIC
PHILADELPHIA
Delaware Bay
N.J. Pinelands National Reserve
Study Area
0
25
km

FIG. 1. Map of NJ Pinelands National Reserve and study area.

TABLE 1. Land Cover/Vegetation Types.

1. Pine/oak forest — >50% *Pinus rigida*	5. Pitch pine lowland forest — *Pinus rigida*/heath understory
2. Oak/pine forest — >50% *Quercus* spp.	6. Non-Pine Barrens vegetation
3. Cedar swamp — *Chamaecyparis thyoides*	7. Water
4. Hardwood swamp — *Acer rubrum, Nyssa sylvatica*	

All digital image analysis for this study was undertaken at the Cook College Remote Sensing Center using ERDAS image processing and GRASS geographic information system software. Supervised classification techniques were used to classify the image into appropriate land cover/community types (Lillesand and Kiefer 1986). A classification scheme was used that was similar to that employed by the NJ Pinelands Commission to map vegetation in 1979 (Pinelands Commission 1980) (Table 1). Aerial photo-interpretation and ground reconnaissance were used to select training sites (representative samples) of each land cover/vegetation type.

The results of the supervised image classification were then compared to visual interpretation of the TM image (in conjunction with aerial photographs and the Pinelands Commission vegetation maps) at approximately 500 random points. Due to particular concern over the status of the cedar swamps in the Pinelands National Reserve (Roman et al. 1987), the utility of TM imagery to delineate these critical ecosystems was further analyzed. Those areas classified as cedar swamps were extracted as a separate digital map layer and compared with a digital map of cedar swamps produced by the Division of Parks and Forestry of the NJ Department of Environmental Protection. The DEP classified cedar swamps into 3 classes: <50% cedar; >50% cedar; and >95% cedar. The DEP's map was based on a visual interpretation of 1986 aerial photographs. A subarea of the Pinelands Reserve Preservation area and a smaller subarea centered on the Great Swamp in the Mullica River Drainage were selected for analysis.

RESULTS

Spectroradiometric analysis of the clipped pitch pine and white cedar foliage shows that the two species have very similar spectral response curves in the 0.4-2.5 µm wavelength range (Fig. 2). In contrast, the spectral radiance curves of selected forest stands from the Landsat TM imagery shows a greater difference between the two vegetation types (Figure 3). In the near IR wavelength range, pine shows a 33% higher response over cedar in the TM data (Fig. 3) as compared to a 6% higher response in the clipped foliage (Fig. 2). This difference between handheld and satellite sensor observations illustrates the fact that in addition to leaf spectral properties, the satellite observed signal is also a function of the canopy structure and background reflectance. White cedar swamps appear extremely dark on the image; "black holes" that effectively trap solar radiation. The high values in TM Band 1 (centered at 0.49 µm) (Fig. 3) are due to atmospheric scattering adding to the earth surface reflectance.

Further analysis of Landsat spectral radiance curves shows that deciduous forest stands (e.g. oak and hardwood swamps), as expected, have much higher reflectance in the near and middle IR as compared to the coniferous forest stands (Fig. 3). Pitch pine lowlands have an intermediate response between pine uplands and white cedar swamps. The presence/absence of vegetation greatly influences the satellite observed signal. Fig. 4 illustrates the transition from bare soil to a sparsely vegetated section of the Pine Plains to a closed canopy pitch pine stand. As the vegetation canopy cover increases, the red (TM Band 3,

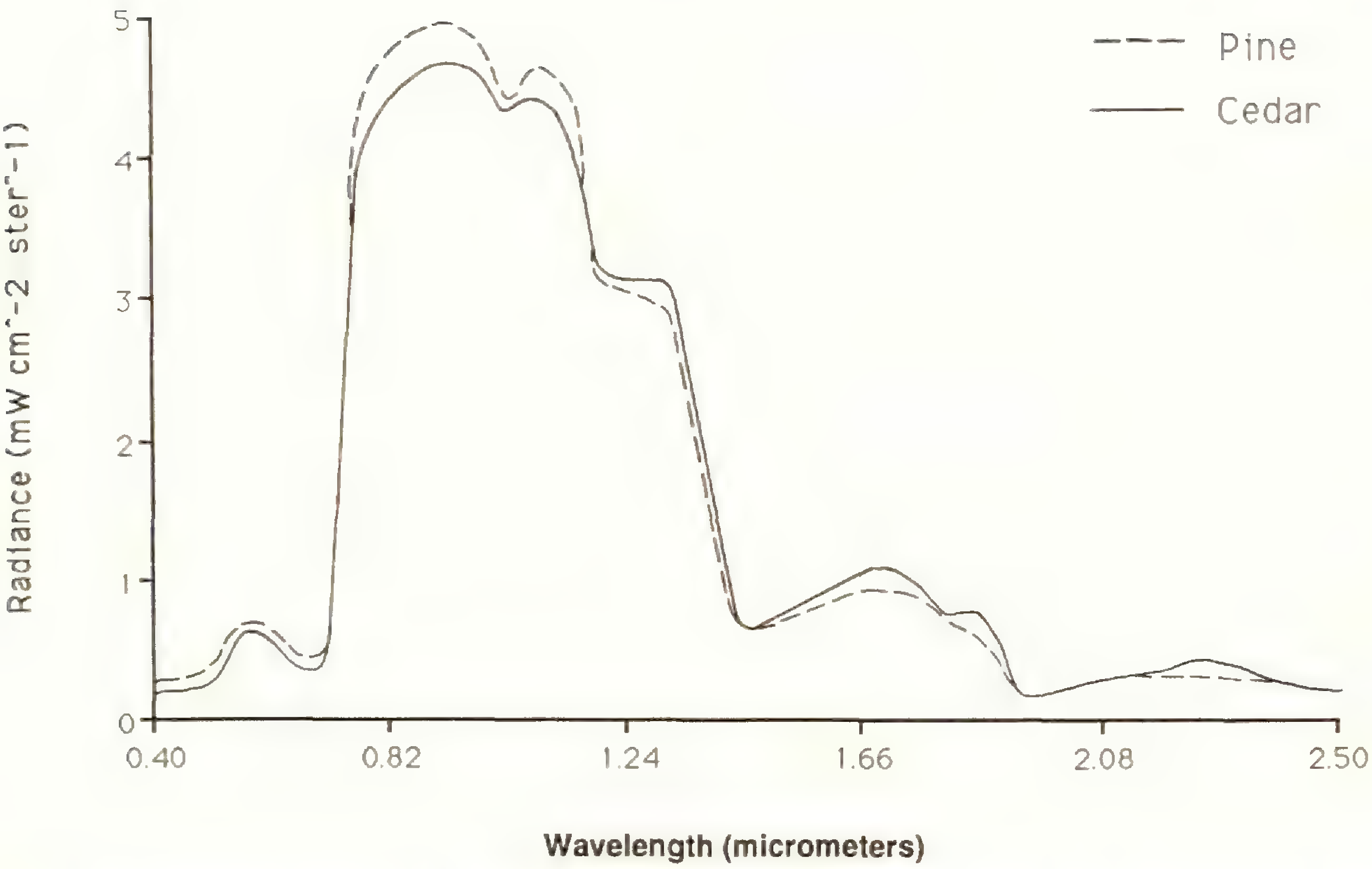

FIG. 2. Plot of spectral radiance vs. wavelength for clipped foliage of *Pinus rigida* and *Chamaecyparis thyoides*.

centered at 0.66 μm) reflectance decreases due to chlorophyll absorption, the near IR (TM Band 4, centered at 0.83 μm) reflectance increases due to intra-leaf scattering and the middle IR (TM Band 5, centered at 1.65 μm) reflectance decreases due to cellular water absorption (Peterson and Running 1989).

Ellipse plots of the training set data show similar relationships as above (Fig. 5). In closed canopy forest stands, there is little difference in red reflectance (TM Band 3) but a gradient in the near IR (TM Band 4) from cedar swamps at the lower extreme to oak forests and hardwood swamps at the upper extreme (Fig. 5a). The response from mixed pine and oak stands is a function of the relative amounts of the darker pine versus the brighter oak in the overstory. In the middle IR (TM Band 5), the pitch pine lowlands generally show a lower response than upland pine/oak forests (Fig. 5b). This lower response may be due to a variation in the understory (e.g. *Kalmia angustifolia* versus *Quercus ilicifolia*) rather than in the overstory.

One unexpected result was the discrimination provided by the thermal IR (TM Band 6, centered on 11.5 μm) (Fig. 5c). The lowland forest types, the cedar and hardwood swamps and to a lesser extent the pitch pine lowlands, showed significantly cooler thermal IR emmittances than the upland forest types. This difference in thermal response, on the order of 3°C, is presumably a function of evapotranspirative cooling due to either standing water or elevated soil moisture levels. The drought conditions at the time of image acquisition may have heightened this difference by further restricting soil moisture levels and evapotranspirative cooling in the upland forests.

Results show that some of the major Pinelands land cover/vegetation types can be discriminated and mapped with Landsat TM data with a reasonable degree of accuracy. The comparison of the automated classification vs. a visual interpretation of the imagery at 489 randomly selected points, shows an overall agreement of 68.3% (Table 2). The percent agreement varies with land cover/vegetation type. For example, the automated classification

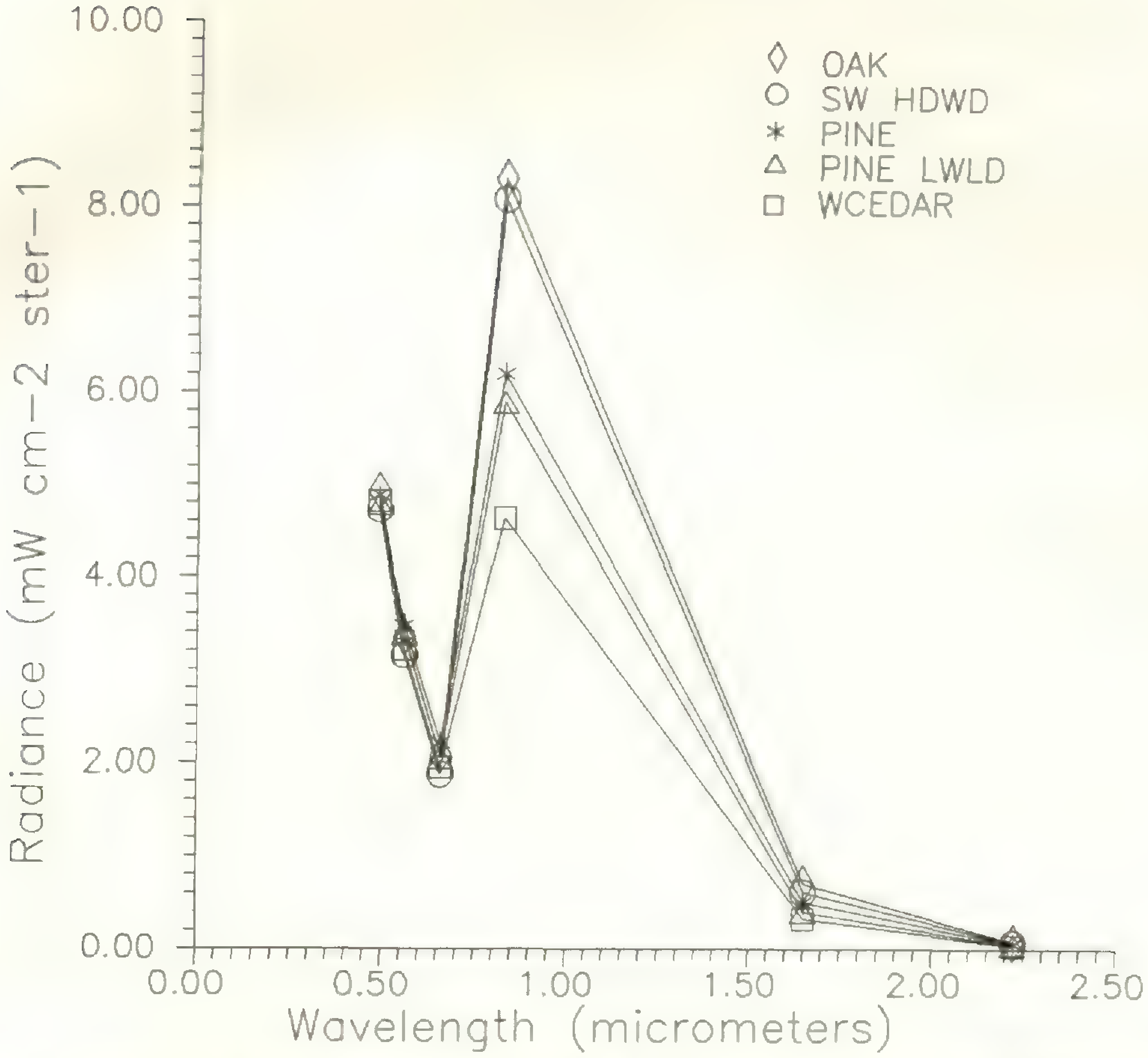

FIG. 3. Plot of spectral radiance vs. TM wavelength bands for pinelands forest vegetation types.

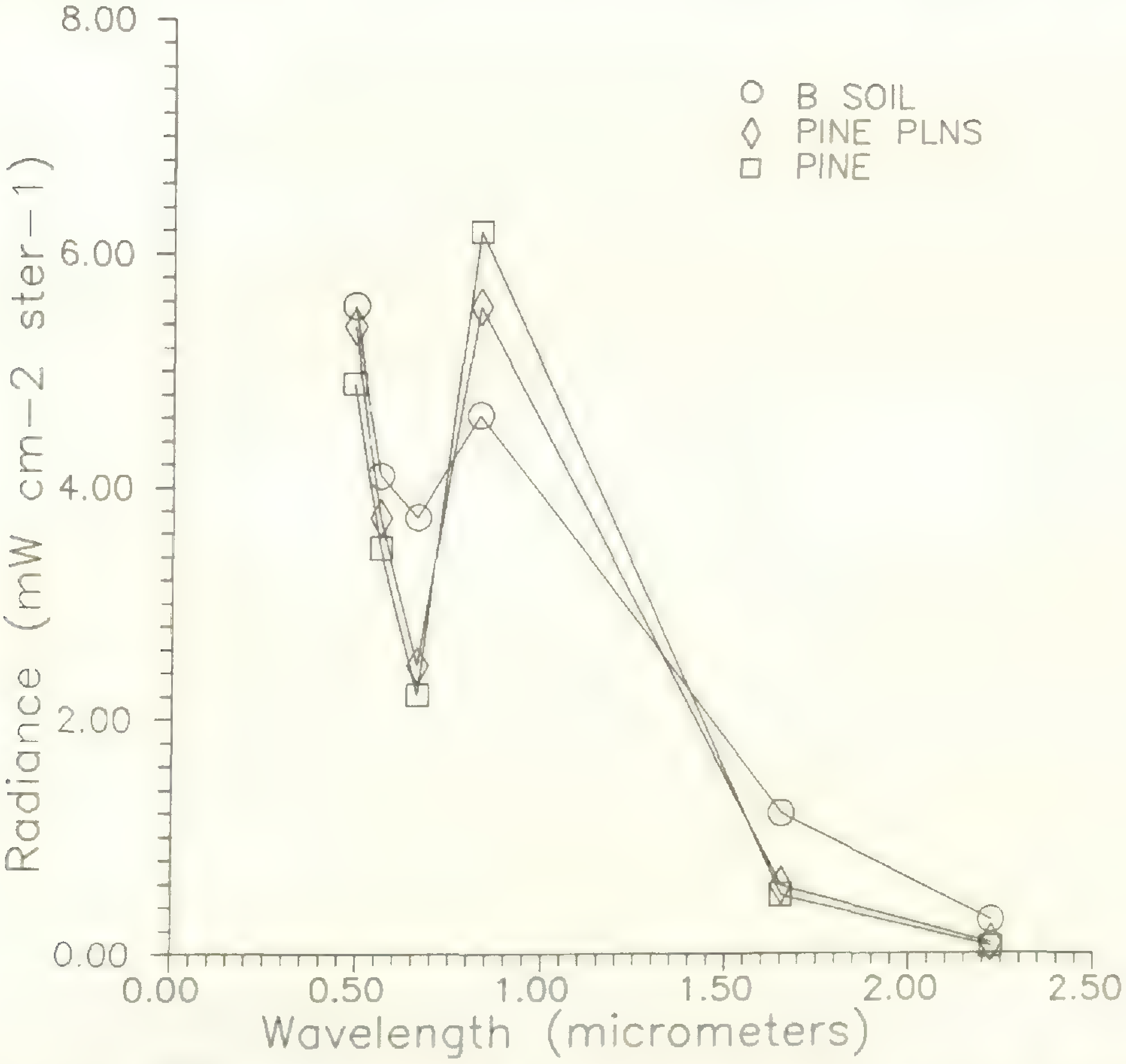

FIG. 4. Plot of spectral radiance vs. TM wavelength bands for transition from bare soil to pine plains to mature pitch pine overstory.

TABLE 2. Annotated classification vs. visual interpretation agreement matrix.

Classified Data	Reference Data PO	OP	HS	PL	CS	Row Totals	Number Correct	Producer's Accuracy	User's Accuracy
pine-oak (PO)	95	18	1	22	1	146	95	68.8%	65.1%
oak-pine (OP)	29	78	14	9	0	133	78	69.6%	58.6%
hardwood swamp (HS)	0	5	7	0	0	12	7	22.6%	58.3%
P pine lowland (PL)	12	9	9	118	4	157	118	78.1%	75.2%
cedar swamp (CS)	0	0	0	2	14	16	14	73.7%	88.0%
non-PB vegetation	2	1	0	0	0	26	22	57.9%	84.6%
Column Totals	138	112	31	151	19	489	334		

Producer's Accuracy: # correct/column total; User's Accuracy: # correct/row total; Overall Classification Agreement = 68.3%.

gave poor results for hardwood swamps which were readily confused with oak-pine forests. This result is not unexpected as the automated classification is based solely on the spectral information and there is a large spectral overlap between hardwood swamps and oak forests. Visual interpretation utilizes spatial as well as spectral information, permitting more subtle discrimination based on spatial context. As in the case of the hardwood swamps, information on patch shape and distance from streams allows more accurate discrimination.

Comparison between the automated classification of Landsat TM and visual interpretation of aerial photographs shows a reasonable agreement (Table 3). The TM classification most closely corresponds to the second two categories: >50% and >95% cedar. The aggregated number of hectares for these two categories varied by ±20-30% from the hectare results of the TM classification. Some of the discrepancies are due to differences in the two methods. The photo-interpreter drew smooth polygons around the cedar swamps often including small inliers of different vegetation that the automated image classification would exclude. The automated methods may misclassify a feature to be a cedar swamp based on spectral information that a photo-interpreter can discriminate as a different land cover/vegetation type based on spatial and textural information.

TABLE 3. Comparison of TM classification and photo-interpretation results of cedar swamps.

	Percentage Area of TM Classified Cedar Swamps	
	Preservation Area	Great Swamp
Photo-Interpretation		
other	40.7%	17.3%
<50% cedar	5.4	5.9
<95% >50% cedar	20.5	6.8
>95% cedar	33.4	70.0

	Area of Cedar Swamp in Hectares	
	Preservation Area	Great Swamp
Photo-Interpretation		
>95% cedar	1278	241
>50% cedar	2245	272
TM Classification		
cedar swamp	2670	210

SUMMARY AND CONCLUSIONS

As demonstrated in other studies of the application of remotely sensing for forest vegetation classification and mapping, one channel from the visible, near IR, and middle IR is needed to adequately characterize the vegetation (Benson and DeGloria 1985, Horler and Ahern 1986, Jensen et al. 1986, Lathrop et al. 1987, Spanner et al. 1984). To further discriminate upland from lowland forest types, the thermal IR band should also be included. The visible wavelength region (e.g. the red band) provides information on the presence/absence of vegetation. The near IR and middle IR provide information to discriminate community types (e.g. oak vs. pine in the near IR, or pine uplands vs. lowlands in the middle IR). The thermal infrared provides critical information on surface temperature and the hydrological regime helping to differentiate upland from lowland forest types which appear cooler. Due to the often sparse pine overstory, the understory vegetation may greatly influence the remote sensing observed signal; the extent of this influence has yet to be determined.

Analysis of the original and classified Landsat TM imagery further confirms ground-based studies (Forman 1979) that the Pinelands landscape is characterized by a complex mosaic of ecological land types: discrete patches or more often corridors of white cedar and hardwood swamps amidst a background matrix of upland pine and oak forests. The upland forests are better characterized by a continuous gradient with pure pine stands on one end grading into pure oak at the opposite. These upland forests in turn grade into pitch pine lowland forests depending on the hydrological regime. The effects of fire disturbance provide an additional dimension overlaid on the above patterns.

Traditional supervised image classification techniques provide reasonably accurate results but can be improved by the incorporation of additional data sets (e.g. soil type, elevation, hydrologic regime) in the context of a geographic information system (GIS). The incorporation of spatial information (e.g. distance from streams) into classification procedures should provide further discrimination among land cover/vegetation types. As part of a longer term investigation of the landscape ecology of the Pinelands system, the Cook College Remote Sensing Center is developing a GIS data base for the Pinelands National Reserve. This GIS data base includes an approximately twenty year archive of Landsat Multispectral Scanner (starting in 1972) and Thematic Mapper (starting in 1982) images. Remote sensing, both satellite and airborne, in concert with GIS technology should provide a more effective means of monitoring the spatial and temporal dynamics of the Pinelands ecosystem.

ACKNOWLEDGMENTS

I wish to acknowledge John Bognar, Sandra Luque, Jim Gasprich and Merlyn Liberty for their efforts in all phases of this study. I thank the NJ Division of Parks and Forestry and the Department of Environmental Protection, specifically Craig Coutros, for making the state's white cedar coverage available. This research was supported by the NJ Agricultural Experiment Station with funding through the McIntire-Stennis program.

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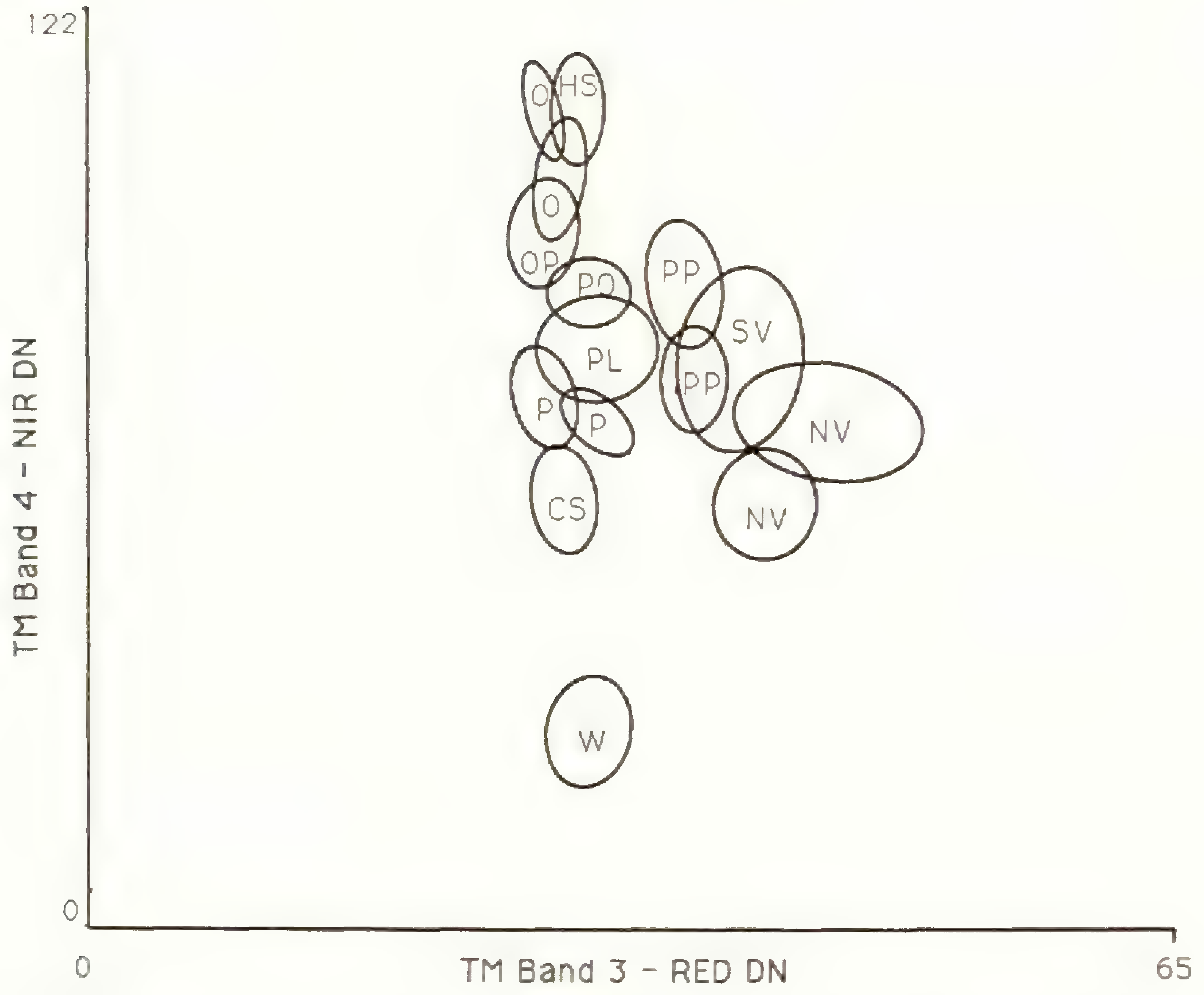

FIG. 5A. Plot of TM classification training set ellipses for TM Band 4 (near IR) vs. Band 3 (red).

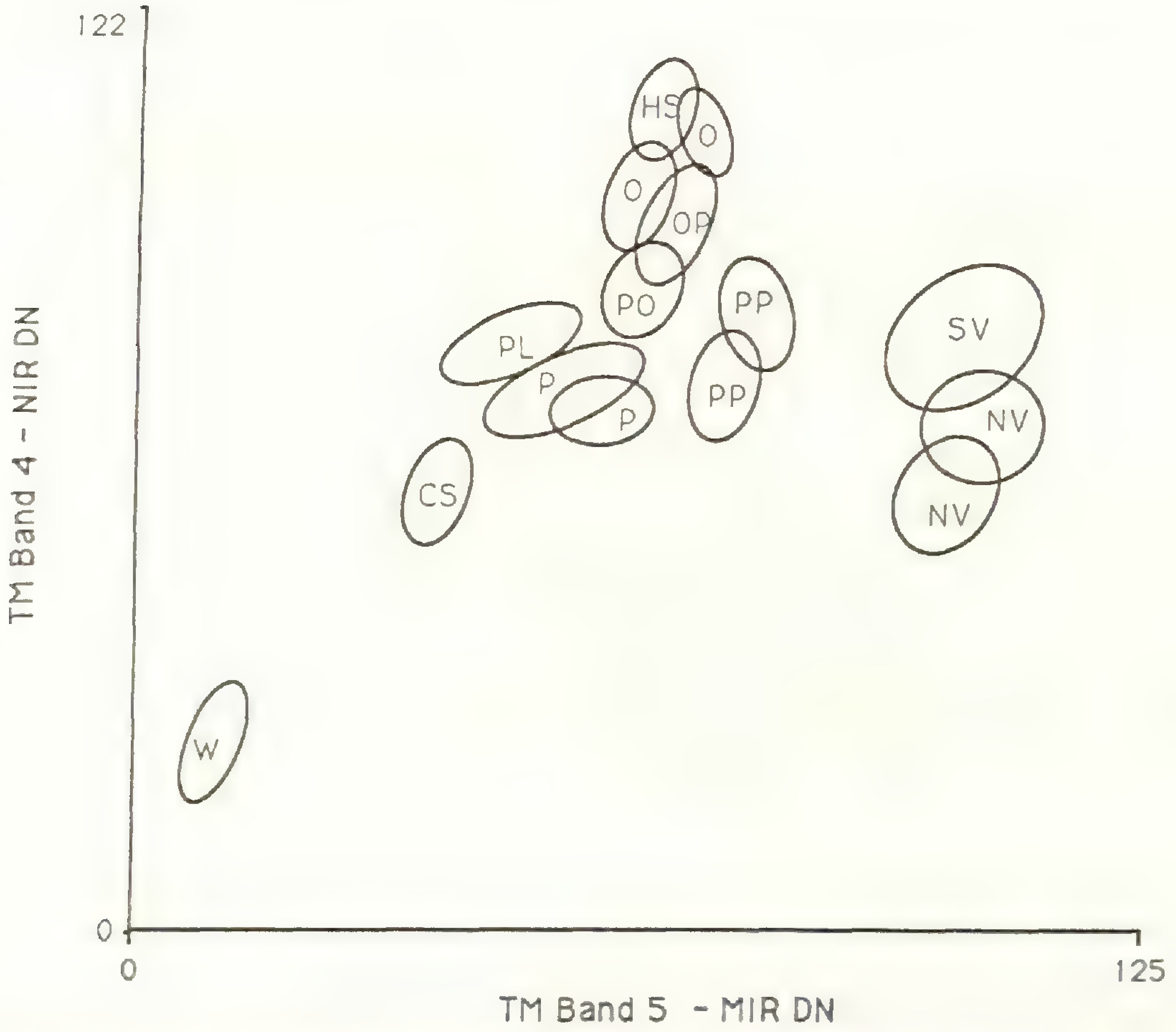

FIG. 5B. Plot of TM classification training set ellipses for TM Band 4 (near IR) vs. Band 5 (mid IR).

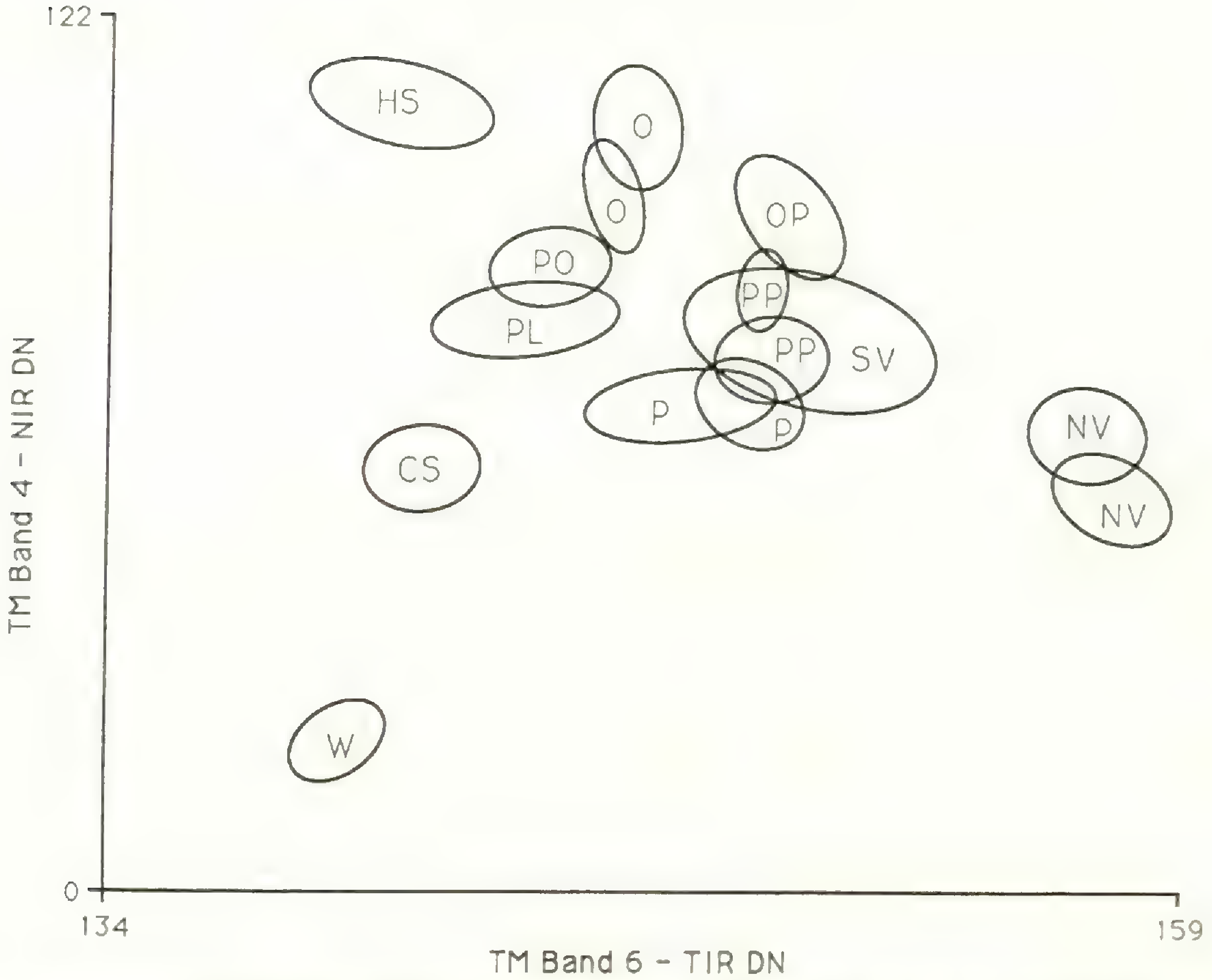

FIG. 5C. Plot of TM classification training set ellipses for TM Band 4 (near IR) vs. Band 6 (thermal IR).

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Bartonia No. 58: 11-21, 1994

Mosses of the New Jersey Pine Barrens and Adjacent Coastal Plain

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This paper presents the first comprehensive published list of the mosses occurring in the New Jersey Pine Barrens, a region which has long been recognized for its unique and highly significant ecosystems (Good and Good 1984). Mosses are a notable component of the Pine Barrens vegetation, especially in the wetlands which occupy 25-35% of the region (Ehrenfeld 1986; Roman and Good 1990). Reviews of the ecological and taxonomical literature on the mosses of the New Jersey Pine Barrens have been made by Forman (1979) and Karlin and Andrus (1988). Although not focused on the Pine Barrens or New Jersey, Crum and Anderson's (1981) treatment of eastern North American mosses is an invaluable source of information. Recent studies have focused on the development of a checklist of New Jersey mosses and the determination of the rare and endangered species of mosses in the state (Andrus and Karlin 1989; Karlin 1990; Karlin and Schaffroth 1992). Listings of endangered moss species already exist for New York (Clemants and Ketchledge 1990), Ohio (Snider 1990) and North Carolina, and one is currently being developed for Pennsylvania (Webster and Manville 1990).

The most prolific collector in southern New Jersey in the 1800's was Coe Finch Austin, who collected both in the Pine Barrens and also in the Palisades of Bergen County. His collections served as the primary source upon which the first listing of New Jersey mosses was formulated (Britton 1881 & 1889). Other collectors between 1850 and 1900 include E. G. and N. L. Britton, G. N. Best, D. C. Eaton, T. P. James and E. A. Rau. The next period of notable activity was during the 1930's, when Bayard Long collected extensively throughout the Pine Barrens region. A number of collections were also made during this time by A. T. Beals, H. Koster and G. M. Tees. Edwin T. Moul collected in the late 1940s and 1950s, and also identified specimens collected by others. Marian Robertson collected extensively in the 1960s; unfortunately many of her specimens were not identified and her collections have yet to be curated. Other active collectors from 1960 until the present include R. E. Andrus, T. Gordon, E. F. Karlin, A. List, W. S. G. Maass, C. F. Reed, W. Olson and G. L. Smith.

METHODS

All available moss specimens collected from the coastal plain region of New Jersey (southern New Jersey) at the Brooklyn Botanic Garden (BKL), Chrysler Herbarium (CHRB), New York Botanical Garden (NY), Academy of Natural Sciences (PH) and State University of New York at Binghamton (BING) were examined. Collections from the Piedmont portions of Mercer and Middlesex Counties were excluded. Using the Pine Barrens boundaries given by McCormick and Forman (1979), all taxa having been collected from the Pine Barrens region were noted. Nomenclature follows Anderson (1990) for *Sphagnum* and Anderson et al. (1990) for all other mosses.

RESULTS AND DISCUSSION

A total of 168 species and 3 varieties of mosses (35 families and 71 genera) have been collected in the New Jersey Pine Barrens; another 36 species occur on the adjacent coastal plain of New Jersey (Table 1). Six of these taxa have only recently been reported for New Jersey (*Bryum uliginosum*, *Fontinalis hypnoides*, *Fontinalis flaccida*, *Leskella nervosa*, *Rhizomnium magnifolium* and *Tetraplodon angustatus*) (Karlin and Schaffroth 1992). This makes a total of 204 species and 3 varieties of mosses (in 37 families and 84 genera) known from southern New Jersey, which is significantly lower than the number of vascular plants: about 850 species reported for the Pine Barrens (Fairbrothers 1979) and approximately 1400 species for all of southern New Jersey (Stone 1911).

The most recent checklist of mosses for North America (Anderson et al. 1990) includes a number of significant taxonomic changes affecting New Jersey taxa. Following Koponen (1968), the genus *Mnium* has been divided up into several genera, with *Mnium*, *Rhizomnium* and *Plagiomnium* being present in southern New Jersey (Table 1). *Drepanocladus* was also split up into several genera, following Tuomikoski (1973), with *Warnstorfia* being the only representative of the complex found in southern New Jersey to date (Table 1). At the species level, all southern New Jersey material of *Plagiomnium affine* is now referable to either *P. ciliare* or *P. ellipticum*, and all southern New Jersey material of *Atrichum undulatum* is now referable to *A. altecristatum* and perhaps *A. oerstedianum*. In addition, *Sphagnum viridum* was split from *S. cuspidatum* (Flatberg 1988) and *S. isoviitae* was split from *S. fallax* (Flatberg 1992). All four of these *Sphagnum* species occur in the Pine Barrens.

Unlike vascular plants, there are no moss species which are endemic to the Pine Barrens. Most of the species are widespread in eastern North America; only 22 taxa (about 11% of the southern New Jersey moss flora) have strong coastal plain affinities (Crum and Anderson 1981; Karlin and Andrus 1988). Several taxa reach the northern (5 taxa) or southern (24 taxa) limits of their geographical coastal plain limits in the Pine Barrens and adjacent coastal plain of New Jersey (Table 1). Interestingly, the ratio of taxa at their northern geographical limits to taxa at their southern geographical limits in this region is quite different for vascular plants (about 7:1) (Fairbrothers 1979) and mosses (about 1:5). This indicates that the biology and ecology of these two groups of plants may be quite different.

Sphagnum are the most ecologically and economically significant mosses in the Pine Barrens, and they also represent the most distinctive aspect of the Pine Barrens moss vegetation. Representing 20% of the total number of moss taxa found in the Pine Barrens (16% of the total in southern New Jersey), *Sphagnum* is the second most species rich plant genus in this region. Only *Carex* has a greater diversity. The *Sphagnum* floras of the coastal plain of New Jersey (33 species and 1 variety) and Long Island (33 species) are the most diverse found on the North American coastal plain (Andrus 1980; Lane and Dubois 1981; Karlin and Andrus 1988; Karlin, Andrus and Reed 1991). Such a high diversity is partly explained by the many species which reach their geographical limits in the Pine Barrens. Several taxa are at their northern (3) or southern (8) geographical coastal plain limits in the Pine Barrens and adjacent coastal plain of New Jersey (Table 1), with three other species being very near their southern limits (Karlin and Andrus 1988; Karlin, Andrus and Reed 1991). Over half of the *Sphagnum* taxa present in this region (16 taxa) have strong coastal plain affinities (Karlin and Andrus 1988).

TABLE 1. The moss taxa presently known to occur in the New Jersey Pine Barrens and the adjacent coastal plain. Taxa occurring on the adjacent coastal plain but not yet collected in the Pinelands are indicated with an asterisk. The date of the most recent collection in each county (or region) is indicated as follows: A = 1975–1990; B = 1950–1974; C = 1900–1949; D = prior to 1900; Z = collection date unknown. Upper case letters indicate two or more collections from that county (or region) and lower case letters stand for only one collection. Taxa at their geographical coastal plain limits in southern New Jersey are indicated by NL (northern limit) or SL (southern limit). The counties and regions are: CM = Cape May; At = Atlantic; Cu = Cumberland; Sa = Salem; Gl = Gloucester; Ca = Camden; Bu = Burlington; Oc = Ocean; Mo = Monmouth; Mi = Middlesex; Me = Mercer; PB = no collection site given other than the Pine Barrens region (Pinelands); SNJ = no collection site given other than southern New Jersey. For *Plagiomnium ciliare* and *P. ellipticum*, a question mark indicates that *Mnium affine* had been collected from that county, but it was not determined whether the specimen was *P. ciliare* or *P. ellipticum*.

	Counties												
Species	CM	At	Cu	Sa	Gl	Ca	Bu	Oc	Mo	Mi	Me	PB	SNJ
Acaulon (Pottiaceae)													
muticum (Hedw.) C. Mull.*	-	-	-	-	-	d	-	d	-	-	-	-	-
Amblystegium (Amblystegiaceae)													
serpens (Hedw.) Schimp. var. *juratzkanum* (Schimp.) Rau & Herv.*	-	-	-	b	-	-	b	-	-	c	-	-	-
varium (Hedw.) Lindb.*	-	-	-	c	-	-	c	-	-	-	-	-	-
Anacamptodon (Fabroniaceae)													
splachnoides (Frol. ex Brid.) Brid.	-	-	-	-	-	b	c	-	-	-	-	-	-
Anomodon (Anomodontaceae)													
attenuatus (Hedw.) Hub.	b	-	C	B	-	c	c	b	-	-	-	-	-
rostratus (Hedw.) Schimp.	B	-	C	C	-	-	-	b	c	-	-	-	-
Atrichum (Polytrichaceae)													
altecristatum (Ren. & Card.) Smyth & Smyth	-	-	c	-	-	-	b	B	-	-	-	-	-
angustatum (Brid.) Bruch & Schimp.	C	C	C	-	C	C	B	B	B	C	-	-	-
crispum (James) Sull.	b	b	-	b	C	B	A	d	D	B	-	-	-
Aulacomnium (Aulacomniaceae)													
heterostichum (Hedw.) Bruch & Schimp.	b	-	-	c	d	-	B	B	c	c	-	-	-
paulstre (Hedw.) Schwaegr.	B	B	C	B	C	B	A	C	c	B	-	d	-
Barbula (Pottiaceae)													
convoluta Hedw.	-	-	-	-	-	-	-	d	-	-	-	d	d
unguiculata Hedw.	-	b	-	-	-	-	B	B	-	-	-	d	-
Bartramia (Bartramiaceae)													
pomiformis Hedw.*	-	-	-	-	-	B	-	-	-	-	-	-	-
Brachythecium (Brachytheciaceae)													
campestre (C. Mull.) Schimp. SL	-	-	-	-	-	-	c	-	-	-	-	-	-
oxycladon (Brid.) Jaegr.	-	c	C	C	-	-	B	-	-	-	-	-	-
plumosum (Hedw.) Schimp.	-	-	-	-	-	-	-	d	-	-	-	-	-
rutabulum (Hedw.) Schimp.	-	-	C	-	-	-	-	-	-	-	-	-	-
salebrosum (Web. & Mohr.) Schimp.	-	C	C	c	d	b	B	-	c	c	-	-	-
Brotherella (Sematophylaceae)													
recurvans (Michx.) Fleisch.	-	-	c	-	-	-	B	d	-	c	-	d	-
Bruchia (Bruchiaceae)													
flexuosa (Sw. ex Schwaegr.) C. Mull.	-	-	-	-	d	d	-	-	-	-	-	-	-
Bryhnia (Brachytheciaceae)													
novae-angliae (Sull. & Lesq.) Grout*	-	-	C	B	-	-	B	B	-	-	-	-	-
Bryoandersonia (Brachytheciaceae)													
illecebra (Hedw.) Robins.	C	c	C	C	-	c	c	B	C	-	-	-	-
Bryoerythrophyllum (Pottiaceae)													
recurvirostre (Hedw.) Chen	-	-	-	-	-	-	b	-	-	-	-	-	-

TABLE 1. Continued

	Counties												
Species	CM	At	Cu	Sa	Gl	Ca	Bu	Oc	Mo	Mi	Me	PB	SNJ
Bryohaplocladium (Leskeaceae)													
microphyllum (Hedw.) Wat. & Iwats.	-	-	-	-	c	-	-	b	-	-	-	-	-
virginianum (Brid.) Wat. & Iwats.	-	-	C	c	B	c	C	-	-	d	-	-	-
Bryum (Bryaceae)													
argenteum Hedw.*	-	-	-	-	-	c	B	-	-	b	-	-	-
caespiticium Hedw.	-	c	C	-	-	c	A	-	c	-	-	-	-
capillare Hedw.	-	-	-	-	-	-	b	-	-	-	-	-	-
lisae De Not. var. *cuspidatum* (Bruch & Schimp.) Marg.*	-	-	-	-	-	-	-	-	c	-	-	-	-
pseudotriquetrum (Hedw.) Gaertn. et al.*	-	-	-	-	-	-	-	-	-	b	-	-	-
uliginosum (Brid.) Bruch & Schimp. SL	-	-	-	-	-	-	-	d	-	-	-	-	-
Buxbaumia (Buxbaumiaceae)													
aphylla Hedw.	C	c	C	C	d	-	A	C	-	-	-	-	-
Callicladium (Hypnaceae)													
haldanianum (Grev.) Crum.	C	-	C	B	C	C	B	C	-	c	-	d	-
Calliergonella													
cuspidata (Hedw.) Loeske	-	-	-	-	-	-	b	-	-	-	-	-	-
Campylium (Amblystegiaceae)													
chrysophyllum (Brid.) J. Lange	-	-	-	-	-	-	a	-	-	-	-	-	-
hispidulum (Brid.) Mitt.	c	-	c	-	-	-	B	-	-	-	-	-	-
radicale (P. Beauv.) Grout*	-	-	c	-	d	-	c	-	-	-	-	-	-
stellatum (Hedw.) C. Jens. SL	-	-	-	c	-	-	-	-	-	-	-	-	-
Ceratodon (Ditrichaceae)													
purpureus (Hedw.) Brid.	b	B	-	B	-	B	A	B	B	d	-	-	-
Climacium (Climaceae)													
americanum Brid.	B	c	C	c	-	-	c	-	-	-	-	-	-
dendroides (Hedw.) Web. & Mohr SL	-	-	-	-	-	-	-	d	-	-	-	-	-
kindbergii (Ren. & Card.) Grout	c	c	C	b	-	-	c	d	-	-	-	-	-
Cratoneuron (Amblystegiaceae)													
filicinum (Hedw.) Spruce*	-	-	-	-	-	-	-	-	d	-	-	-	-
Cryphaea (Cryphaeaceae)													
glomerata Bruch & Schimp. NL	-	-	-	-	-	-	d	-	-	-	-	-	-
Desmatodon (Pottiaceae)													
obtusifolius (Schwaegr.) Schimp.	-	-	-	-	-	-	-	-	-	-	-	-	d
Dicranella (Dicranaceae)													
cerviculata (Hedw.) Schimp. SL	-	-	-	-	-	-	d	-	-	-	-	d	-
heteromalla (Hedw.) Schimp.	B	B	B	c	d	B	B	B	C	B	-	d	-
rufescens (With.) Schimp.*	-	-	-	-	-	-	-	-	d	-	-	-	-
varia (Hedw.) Schimp.	-	-	-	-	-	d	-	-	-	-	-	d	-
Dicranum (Dicranaceae)													
condensatum Hedw.	B	-	b	b	B	-	B	B	D	-	-	C	-
flagellare Hedw.	B	c	C	c	B	-	A	B	B	-	-	d	-
fuscescens Turn.	-	-	-	-	-	-	b	b	-	d	-	-	-
montanum Hedw.	-	-	c	c	-	-	B	-	b	-	-	-	-
ontariense Peters	-	-	-	-	-	-	-	b	-	-	-	-	d
polysetum Sw.	-	-	b	-	-	-	-	-	-	-	-	-	-
scoparium Hedw.	B	B	C	B	C	B	B	B	B	B	-	-	-
spurium Hedw.	-	-	-	-	-	B	-	D	-	d	-	d	-
Didymodon (Pottiaceae)													
fallax (Hedw.) Zand.	-	-	-	-	-	-	b	-	-	-	-	-	-
Diphyscium (Buxbaumiaceae)													
foliosum (Hedw.) Mohr.	-	-	C	-	C	C	B	-	C	C	C	-	-

TABLE 1. Continued

Species	Counties												
	CM	At	Cu	Sa	Gl	Ca	Bu	Oc	Mo	Mi	Me	PB	SNJ
Ditrichum (Ditrichaceae)													
lineare (Sw.) Lindb.	-	-	-	-	-	d	B	z	c	-	-	-	d
pallidum (Hedw.) Hampe	C	B	C	B	-	-	B	B	-	b	-	-	-
pusillum (Hedw.) Hampe*	-	-	c	-	c	-	-	-	c	-	-	-	-
Drummondia (Orthotrichaceae)													
prorepens (Hedw.) E.G. Britt.	-	-	-	-	d	-	-	-	d	-	-	-	-
Entodon (Entodonaceae)													
cladorrhizans (Hedw.) C. Mull.	-	C	-	-	-	-	-	-	-	-	-	-	-
compressus (Hedw.) C. Mull. NL	-	-	-	-	-	-	-	c	-	-	-	-	-
seductrix (Hedw.) C. Mull.	c	c	C	c	-	-	B	C	-	-	-	-	-
Ephemerum (Ephemeraceae)													
crassinervum (Schwaegr.) Hampe*	-	-	-	-	-	d	-	-	-	-	-	-	-
spinulosum Bruch & Schimp.	-	-	-	-	-	d	d	-	-	-	-	-	-
Eurhynchium (Brachytheciaceae)													
pulchellum (Hedw.) Jenn.	-	c	c	c	-	-	-	-	c	-	-	-	-
Fissidens (Fissidentaceae)													
bryoides Hedw.*	-	-	-	-	-	-	b	-	-	-	-	-	-
dubius P. Beauv.	-	-	c	-	-	-	a	-	-	-	-	-	-
fontanus (B. Pyl.) Steud.*	-	-	-	-	-	-	b	-	-	-	-	-	-
osmundioides Hedw.	-	-	-	-	-	d	-	-	-	-	-	-	-
Fontinalis (Fontinalaceae)													
flaccida Ren. & Card.	-	c	-	-	-	-	-	B	-	-	-	-	D
hypnoides Hartm. SL	-	-	a	-	-	-	-	-	-	-	-	-	-
novae-angliae Sull. var. *novae-angliae*	-	b	C	-	-	-	-	C	-	b	d	-	-
var. *cymbifolia* (Aust.) Welch	-	-	-	-	-	-	-	D	-	-	-	-	d
sullivantii Lindb.	-	c	d	-	-	-	-	-	-	-	-	-	-
Forsstroemia (Leptodonaceae)													
trichomitria (Hedw.) Lindb.	-	-	-	B	-	-	d	-	-	-	-	-	-
Funaria (Funariaceae)													
flavicans Michx.*	-	-	c	-	-	-	-	-	-	-	-	-	-
hygrometrica Hedw.	-	B	C	-	-	-	c	d	-	B	-	-	-
Haplohymenium (Anomodontaceae)													
triste (Ces. in De Not) Kinb.	-	-	c	-	-	-	a	-	-	-	-	-	-
Helodium (Helodiaceae)													
paludosum (Sull.) Aust.	-	-	c	b	C	c	B	A	-	-	-	-	-
Herzogiella (Hypnaceae)													
striatella (Brid.) Iwats.	b	-	c	C	-	-	B	B	-	-	-	-	d
turfacea (Lindb.) Iwats.	-	-	-	-	-	-	C	-	-	-	-	-	-
Homalotheciella (Brachytheciaceae)													
subcapillata (Hedw.) Broth.	-	c	-	-	-	-	-	-	-	-	-	-	-
Hypnum (Hypnaceae)													
cupressiforme Hedw.	-	-	C	C	C	c	C	c	-	-	-	-	-
curvifolium Hedw.*	-	-	-	-	-	-	B	-	-	-	-	-	-
imponens Hedw.	B	C	-	C	c	b	B	B	B	b	c	d	-
lindbergii Mitt.	-	-	c	-	-	-	c	-	-	-	-	-	-
pallescens (Hedw.) P. Beauv.	-	-	-	-	-	b	B	-	-	-	-	-	-
pratense (Rabenh.) W. Koch	-	-	-	-	-	-	-	-	-	-	-	D	-
Isopterygium (Hypnaceae)													
tenerum (Sw.) Mitt.	C	-	B	c	C	B	B	b	C	-	-	D	-
Leptobryum (Bryaceae)													
pyriforme (Hedw.) Wils.	-	-	c	c	-	-	-	-	c	-	-	D	-

TABLE 1. Continued

Species	Counties												
	CM	At	Cu	Sa	Gl	Ca	Bu	Oc	Mo	Mi	Me	PB	SNJ
Leptodictyum (Amblystegiaceae)													
riparium (Hedw.) Warnst.*	-	-	c	c	-	-	-	-	-	-	-	-	-
humile (P. Beauv.) Ochyra	-	-	-	-	-	-	B	-	-	-	-	-	-
Leskea (Leskeaceae)													
gracilescens Hedw.*	c	-	-	-	c	-	-	-	-	-	-	-	-
obscura Hedw.*	-	-	-	-	-	-	B	-	-	-	-	-	-
polycarpa Hedw.	-	-	c	-	-	-	d	-	-	C	c	-	-
Leskella (Leskeaceae)													
nervosa (Brid.) Loeske* SL	-	-	c	-	c	-	-	-	-	-	-	-	-
Leucobryum (Leucobryaceae)													
albidum (Brid.) Lindb.	c	b	-	-	-	d	A	b	-	-	-	-	-
glaucum (Hedw.) Angstr.	C	c	C	C	C	C	B	B	C	C	-	-	-
Leucodon (Leucodontaceae)													
julaceus (Hedw.) Sull.	-	C	C	c	-	-	c	-	-	-	-	-	-
Micromitrium (Ephemeraceae)													
austinii Sull.*	-	-	-	-	-	-	-	-	c	-	-	-	-
megalosprum Aust.*	-	-	-	-	-	d	-	-	-	-	-	-	-
synoicum (James) Aust.*	-	-	-	-	c	d	-	-	-	-	-	-	-
Mnium (Mniaceae)													
ambiguum H. Mull.*	-	-	-	-	-	-	-	-	-	b	-	-	-
hornum Hedw.	-	-	C	b	-	c	B	C	C	c	-	-	-
marginatum (With.) Brid.	-	-	-	-	-	-	-	c	-	-	-	-	-
stellare Hedw.*	-	-	-	-	-	-	c	-	-	-	-	-	-
Orthotrichium (Orthotrichaceae)													
ohioense Sull. & Lesq.	-	-	C	c	d	d	-	-	-	-	-	-	-
pumilum Sw.	-	-	C	c	c	-	-	-	-	-	-	-	-
pusillum Mitt.	-	c	-	c	-	-	c	-	-	-	-	-	-
sordidum Sull. & Lesq. SL	c	C	C	C	-	-	-	-	-	-	-	-	-
speciosum Nees var. *elegans* (Schwaegr.) Warnst. SL	-	-	-	-	-	-	d	-	-	-	-	-	-
stellatum Brid.	-	-	C	-	C	-	C	d	-	-	-	-	-
Phascum (Pottiaceae)													
cuspidatum Hedw.*	-	-	-	-	-	-	-	-	-	-	c	-	-
Physcomitrium (Funariaceae)													
immersum Sull.	-	-	-	-	-	D	-	-	-	-	-	-	-
pyriforme (Hedw.) Hampe*	c	-	C	C	-	D	-	-	c	C	-	d	-
Plagiomnium (Mniaceae)													
ciliare (C. Mull.) T. Kop.	?	-	C	?	c	-	?	B	c	?	-	-	-
cuspidatum (Hedw.) T. Kop.	b	-	-	C	C	-	B	B	d	C	-	-	-
ellipticum (Brid.) T. Kop. SL	?	-	C	?	C	c	?	c	-	?	-	-	-
Plagiothecium (Plagiotheciaceae)													
cavifolium (Brid.) Iwats.	-	-	C	C	-	B	-	B	-	b	-	-	-
denticulatum (Hedw.) Schimp.	-	-	-	-	-	-	b	-	-	c	-	d	-
Platygyrium (Hypnaceae)													
repens (Brid.) Schimp.	C	c	C	B	-	c	B	d	-	-	-	-	-
Pleuridium (Ditrichaceae)													
palustre (Bruch & Schimp.) Bruch & Schimp.	-	-	-	-	-	-	d	-	-	-	-	-	-
ravenelii Aust.	-	-	-	-	-	-	-	d	-	-	-	-	-
subulatum (Hedw.) Rabh.	c	c	C	c	-	C	-	d	-	-	-	-	-
Pleurozium (Hylocomiaceae)													
schreberi (Brid.) Mitt.	-	-	C	-	-	-	b	d	d	-	-	-	-

TABLE 1. Continued

Species	Counties												
	CM	At	Cu	Sa	Gl	Ca	Bu	Oc	Mo	Mi	Me	PB	SNJ
Pogonatum (Polytrichaceae)													
brachyphyllum (Michx.) P. Beauv.	B	c	c	c	C	c	C	d	C	-	-	d	-
pensilvanicum (Hedw.) P. Beauv.	B	-	-	-	a	-	B	-	C	-	-	-	-
Pohlia (Bryaceae)													
annotina (Hedw.) Lindb.	-	-	-	-	-	-	b	-	-	-	-	-	-
elongata Hedw. SL	-	-	-	-	-	-	-	-	-	-	-	d	-
nutans (Hedw.) Lindb.	C	c	C	C	C	C	B	B	C	B	C	-	-
wahlenbergii (Web. & Mohr) Andrews*	-	-	-	-	-	-	b	-	d	-	-	-	-
Polytrichum (Polytrichaceae)													
commune Hedw. var. *commune*	A	B	C	C	C	B	A	B	C	B	d	d	-
var. *perigoniale* (Michx.) Hampe	-	-	-	-	-	-	c	-	-	-	-	-	-
juniperum Hedw.	B	B	C	C	C	B	B	B	C	-	-	-	-
ohioense Ren. & Card.	C	C	B	b	C	B	B	B	c	-	-	-	-
piliferum Hedw.	C	-	A	-	C	B	B	C	-	C	-	-	-
strictum Brid.	-	-	-	-	-	-	-	d	-	-	-	-	-
Pseudotaxiphyllum (Hypnaceae)													
elegans (Brid.) Iwats.*	-	-	-	c	-	-	b	-	-	-	-	-	-
Ptychomitrium (Ptychomitriaceae)													
incurvum (Schwaegr.) Spruce*	-	-	-	-	-	-	-	-	-	c	-	-	-
Pylaisiadelpha (Hynaceae)													
tenuirostris (Bruch & Schimp.) Buck*	-	-	-	-	-	-	-	-	c	-	-	-	-
Pylaisiella (Hypnaceae)													
intricata (Hedw.) Grout	-	-	-	-	-	-	d	-	-	-	-	-	-
polyantha (Hedw.) Grout	-	c	c	-	-	-	-	-	-	-	-	-	-
selwynii (Kindb.) Crum et al.	-	-	c	c	-	-	-	-	-	-	-	-	-
Rhizomnium (Mniaceae)													
magnifolium (Horik.) T. Kop.* SL	-	-	c	-	-	-	-	-	-	-	-	-	-
punctatum (Hedw.) T. Kop.	-	-	-	-	-	-	-	B	-	-	-	-	-
Rhytidiadelphus (Hylocomiaceae)													
triquetrus (Hedw.) Warnst.	-	-	-	-	-	-	-	d	-	-	-	-	-
Schistidium (Grimmiaceae)													
apocarpum (Hedw.) Bruch. & Schimp.	-	-	-	c	-	-	-	-	-	-	-	-	-
Sphagnum (Sphagnaceae)													
affine Ren. & Card.	A	B	A	A	A	-	A	d	d	-	-	-	-
angermanicum Melin SL	a	-	-	-	-	-	A	A	-	-	-	-	-
austinii Sull. ex Aust. SL	-	-	-	-	d	-	-	D	-	-	-	-	-
bartlettianum Warnst.	a	A	A	-	A	B	A	A	A	a	-	-	-
carolinianum Andrus NL	-	-	-	-	-	-	A	-	-	-	-	-	-
compactum DC	-	A	d	d	-	-	A	A	-	-	-	-	-
cuspidatum Hoffm.[1]	A	A	A	-	A	B	A	A	-	a	-	-	-
cyclophyllum Sull. & Lesq.	-	b	-	-	d	-	A	A	-	-	-	-	-
fallax (Klinggr.) Klinggr.[2]	A	A	A	-	A	B	A	A	b	a	-	-	-
fimbriatum Wils.	-	-	A	a	A	-	A	A	A	a	-	-	-
flavicomans (Card.) Warnst.	a	A	A	-	-	b	A	A	-	a	-	-	-
fuscum (Schimp. Klinggr. SL	-	-	-	-	-	-	-	-	a	a	-	-	-
henryense Warnst.	-	-	A	-	A	A	a	A	a	a	-	-	-
lescurii Sull.	A	B	A	A	A	A	A	A	A	b	A	-	-
macrophyllum Brid. var. *macrophyllum*	A	b	b	-	d	-	d	A	-	-	-	-	-
var. *floridanum* Aust. NL	b	b	-	-	-	-	-	-	-	-	-	-	-
magellanicum Brid.	a	A	A	-	A	A	A	A	a	a	-	-	-
molle Sull.	a	A	a	-	-	-	A	A	-	-	-	-	-
palustre L.	A	A	A	a	A	d	b	A	A	A	-	-	-

TABLE 1. Continued

Species	Counties												
	CM	At	Cu	Sa	Gl	Ca	Bu	Oc	Mo	Mi	Me	PB	SNJ
Sphagnum (continued)													
papillosum Lindb.	A	A	A	-	A	b	A	A	b	-	-	-	-
perichaetiale Hampe NL	d	B	-	-	-	-	A	A	-	-	-	-	-
platyphyllum (Braithw.) Warnst. SL	-	-	-	-	-	-	-	-	-	a	-	-	-
portoricense Hampe	a	d	-	-	-	-	A	A	-	-	-	-	-
pulchrum (Braithw.) Warnst. SL	a	A	A	-	-	A	A	A	-	a	-	-	-
pylaesii Brid.	-	B	d	-	-	-	A	B	-	-	-	-	-
recurvum P. Beauv.	a	A	A	a	A	-	A	A	A	a	-	-	-
rubellum Wils. SL	-	a	a	-	-	-	A	A	-	-	-	-	-
strictum Sull.	-	d	-	-	-	-	A	-	-	-	-	-	-
tenellum (Brid.) Brid. SL	-	d	-	-	-	-	A	A	-	-	-	-	-
tenerum Sull. & Lesq.	-	A	A	d	-	b	A	A	-	a	-	-	-
torreyanum Sull.	a	A	A	d	A	-	A	A	b	a	-	-	-
trinitense C. Mull.	a	A	A	-	a	-	A	A	-	-	-	-	-
Splachnum (Splachnaceae)													
ampullaceum Hedw. SL	-	-	-	-	-	-	d	-	-	-	-	-	-
pennsylvanicum (Brid.) Grout	-	-	-	-	-	-	d	-	-	-	-	d	d
Steerecleus (Brachytheciaceae)													
serrulatus (Hedw.) Robins.	B	C	C	B	C	-	B	B	c	-	-	d	-
Taxiphyllum (Hypnaceae)													
deplanatum (Bruch & Schimp.) Fleisch.	-	-	-	-	-	-	-	b	-	-	c	-	-
taxirameum (Mitt.) Fleisch.	-	-	c	-	-	-	-	-	-	-	-	-	-
Tetraphis (Tetraphidaceae)													
pellucida Hedw.	-	B	C	B	C	b	A	b	C	B	c	-	-
Tetrapolodon (Splachnaceae)													
angustatus (Hewd.) Bruch & Schimp. SL	-	-	-	-	-	-	D	-	-	-	-	-	-
Thelia (Theliaceae)													
asprella Sull.	B	B	C	B	-	C	B	B	d	-	c	-	-
hirtella (Hedw.) Sull.	B	B	C	B	C	c	B	B	B	-	-	-	-
lescurii Sull.	c	C	C	-	C	b	B	B	-	-	-	-	-
Thuidium (Thuidiaceae)													
delicatulum (Hedw.) Schimp.	B	-	C	B	C	-	A	B	C	d	-	-	-
recognitum (Hedw.) Lindb.*	-	-	-	-	d	-	-	-	-	-	-	-	-
Tortella (Porttiaceae)													
humilis (Hedw.) Jenn.	B	B	-	-	C	C	B	C	d	-	-	-	-
Tortula (Pottiaceae)													
muralis Hedw.	-	-	-	-	-	-	B	-	-	-	-	-	-
papillosa Wils.	-	-	-	-	-	-	D	-	-	-	-	-	-
Trematodon (Bruchiaceae)													
longicollis Michx.	-	-	-	-	-	-	B	d	-	-	-	-	-
Ulota (Orthotrichaceae)													
coarctata (P. Beauv.) Hammar	-	-	-	-	d	-	-	-	-	-	-	-	-
crispa (Hedw.) Brid.	-	C	C	C	c	C	C	-	-	-	-	-	-
Warnstorfii (Amblystegiaceae)													
exannulatus (Schimp.) Loeske SL	-	-	-	-	-	A	-	-	-	a	-	d	-
fluitans (Hedw.) Loeske SL	-	-	b	-	-	c	-	d	-	-	-	-	-
Weissia (Pottiaceae)													
controversa Hedw.	-	b	C	-	-	-	B	-	-	-	-	-	-

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[1] Includes *Sphagnum viridum* Flatb.

[2] Includes *Sphagnum isoviitae* Flatb.

Three (*S. austinii*, *S. macrophyllum* var. *floridanum*, *S. strictum*) of the nine *Sphagnum* species that are critically imperiled (having an S1 status) or historic (SH) in the state are limited, in New Jersey, to the coastal plain region (Andrus and Karlin 1989, Office of Natural Lands Management 1992; Karlin and Shaffroth 1992). *Sphagnum austinii*, for which the type collection was made by C.F. Austin in the Pine Barrens, has not been collected in New Jersey in over 100 years (Table 1), and attempts to relocate it have not been successful. As habitat suitable for its existence still occurs in the Pine Barrens, there is a possibility that *S. austinii* still persists there. *Sphagnum platyphyllum*, also critically imperiled in New Jersey, was recently found in the Pine Barrens for the first time.

In contrast to *Sphagnum*, the dung mosses (Splachnaceae) are among the rarest mosses in the Pine Barrens. These unique mosses are usually found growing on dung or animal remains, with some species having their spores dispersed by insects (Crum and Anderson 1981). Three species of dung mosses have been collected in the Pine Barrens: *Splachnum pensylvanicum*, *S. ampullaceum*, and *Tetraplodon angustatus*. All three have apparently not been found in the Pine Barrens in over 100 years (Table 1). The two genera have different habitat requirements. *Splachnum* is associated with the dung of herbivores and *Tetraplodon* is associated with the dung of carnivores.

A large percentage of the mosses of southern New Jersey are currently only known from historical collections. For instance, 79 taxa (38% of the total) were last collected prior to 1950, with 34 of these having not been collected since the late 1800s (Table 1). And, although the more common and easily noted species have been collected from a number of locations, 48 taxa (23% of the total) are only known from one site each (Table 1). Aside from *Sphagnum* (Karlin and Andrus 1988; Andrus and Karlin 1989), there is a significant lack of current data on the occurrence, distribution and ecology of most mosses in the Pine Barrens.

ACKNOWLEDGEMENTS

I am grateful for the assistance provided by Dick Andrus (BING), William Buck (NY), Janice Meyer (CHRB), Steve Clemants (BKL), Kerry Barringer (BKL), Christine Manville (PH) and Ernie Schuyler (PH). I also greatly appreciate Kim Schaffroth's help with the updating of the taxonomy and the recording of specimens at NY. Bruce Allen (Missouri Botanical Garden) verified some of the *Fontanis* collections.

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APPENDIX

SELECTED SPECIMENS EXAMINED

Only those species which are represented by one collection or which have recently been reported as new state records (Karlin and Schaffroth 1992) are listed.

Brachythecium campestre: BURLINGTON: Herman, Koster 13 XII 1939 (NY). *Brachythecium plumosum*: OCEAN: Tom's River, Austin 1868 (NY). *Bryoerythrophyllum recurvirostre*: BURLINGTON: NE corner of Riverton Twp., Robertson 4121 (PH). *Bryum capillare*: BURLINGTON: Nash 19 IV 1968 (CHRB). *Bryum lisae* var. *cuspidatum*: MIDDLESEX: Lake Farrington, Moul 7377 (CHRB). *Bryum pseudotriquetrum*: MIDDLESEX: Englishtown Road, south of Old Bridge, Moul 8729 (CHRB). *Bryum uliginosum*: OCEAN: Tom's River, Austin 1868 (NY). *Calliergonella cuspidata*: BURLINGTON: New Nature Trail, betwen Mullica River and Batsto, Robertson 4439 (PH). *Campylium chrysophyllum*: BURLINGTON: adjacent to old site of Martha's Furnace near Oswego River, Zanoni 4874 (NY). *Campylium stellatum*: SALEM: N of Brotmanville, Long 999a (PH). *Climacium dendroides*:

OCEAN: in swamps about Closter (Bergen Co.) and Tom's River, Austin Musci Appal. 286 (NY). *Cratoneuron filicinum*: MONMOUTH: banks of Manasquan, N.L. Britton 26 VII 1882 (CHRB). *Cryphaea glomerata*: BURLINGTON: Batsto, Austin VI 1855 (NY). *Desmatodon obtusifolius*: Closter and southern New Jersey, Austin Musci Appal. 122 (NY). *Dicranella rufescens*: MONMOUTH: Swimming River above Red Bank, N.L. Britton 2 X 1886 (CHRB). *Dicranum polysetum*: CUMBERLAND: woods 0.25 mile NNW Menantico Creek, Robertson 3143 (PH). *Didymodon fallax*: BURLINGTON: Harrisville, 6.5 miles NW of New Gretna, Robertson 4812 (PH). *Entodon compressus*: OCEAN: Lakewood, near head of lake, Beals 15 VI 1942 (NY). *Ephemerum crassinervum*: CAMDEN: Camden, Austin X 1868 (NY). *Fissidens bryoides*: BURLINGTON: Pompeston Creek, N Broad Street, Riverton Twp., Robertson 4807 (PH). *Fissidens fontanus*: BURLINGTON: Riverton Park, between old lily pond and Pompeston Creek, Robertson 4790 (PH). *Fissidens osmundioides*: CAMDEN: Atco, 1882 (NY). *Fontinalis flaccida*: ATLANTIC: May's Landing, Kaiser 20 VI 1914 (NY); OCEAN: Tom's River, Austin 1868 (NY). *Fontinalis hypnoides*: CUMBERLAND: Manumuskin River at Manumuskin, Forren 26 VI 1976 (PH). *Funaria flavicans*: CUMBERLAND: S of Delmont, Long 1925 (PH). *Homalotheciella subcapillata*: ATLANTIC: Dorothy, Long 2165 (PH). *Leskella nervosa*: CUMBERLAND: Bridgeton, along Racops Run, Long 1124 (PH); GLOUCESTER: 0.5 mile S of Downer, Long 2184 (PH). *Micromitrium austinii*: MONMOUTH: Swan's Pond, Highlands, Haynes 7 X 1911 (NY). *Micromitrium megalosprum*: CAMDEN: broken damp ground about Closter (Bergen Co.) and Camden, Austin Musci Novae-Caesarenses 52 (NY). *Mnium ambiguum*: MIDDLESEX: Ireland Brook, 2.5 miles NNW of Helmetta, Moul 6993 (CHRB). *Mnium marginatum*: OCEAN: Tom's River, between Lakewood and Lakehurst, Weikert 27 IX 1941 (NY). *Mnium stellare*: BURLINGTON: W of Vincentown, Long 1572 (PH). *Orthotricum speciosum* var. *elegans*: BURLINGTON: Batsto, James VIII 1858 (NY). *Phascum cuspidatum*: MERCER: near North Crosswicks, Camberlin *et al.* 16 III 1912 (NY). *Pleuridium palustre*: BURLINGTON: James 25 IV 1854 (NY). *Pleuridium ravenelii*: OCEAN: Farrago, Austin 14 VI 1869 (NY). *Pohlia annotina*: BURLINGTON: Sim Place, Robertson 5736 (PH). *Pohlia elongata*: Pines of New Jersey, C.F. Austin VI 1863 (BKL). *Polytrichum commune* var. *perigoniale*: BURLINGTON: 2 mi. ENE of Berlin, Moul 2452 (PH). *Polytrichum strictum*: OCEAN: Manchester, Eaton 26 VI 1862 (NY). *Ptychomitrium incurvum*: MIDDLESEX: 1.5 mi NW of Monmouth Junction, Long 2966 (PH). *Pylaisiadelpha tenuirostris*: MONMOUTH: Prospertown, near Freehold, Beals 14 V 1933 (NY). *Pylaisiella intricata*: BURLINGTON: Brown's Mills, Best 28 V 1892 (NY). *Rhizomnium magnifolium*: CUMBERLAND: Sarah Run, N of Marlboro, Long 1040 (PH). *Rhytidiadelphus triquetrus*: MONMOUTH: Lakewood, Small 14 IV 1894 (NY). *Schistidium apocarpum*: SALEM: Big Mannington Hill, Portertown, Long 2080 (PH). *Sphagnum platyphyllum*: MIDDLESEX: Helmetta pond, Karlin 9302-0125 (BING). *Splachnum ampullaceum*: BURLINGTON: Quaker Bridge, Tatnall (PH). *Taxiphyllum taxirameum*: CUMBERLAND: S of Leaning Mills, Long 607 (PH). *Tetraplodon angustatus*: BURLINGTON: Quaker Bridge, Greene (NY). *Thuidium recognitum*: GLOUCESTER: Jennings, Swedesboro, Lippinicott 13 XI 1898 (PH). *Ulota coarctata*: GLOUCESTER: Newfield, Ellis 29 X 1893 (NY).

Bartonia No. 58: 23-28, 1994

Interactions Between Research and Management: Examples from the New Jersey Pine Barrens

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There is a special mystique about the odd and unique. Taxonomists who tire of cataloguing the common flora are often drawn to what is rare or unusual. Many ecologists also are attracted to unusual or unique ecosystems. An ecosystem is deemed of special value because it has species at the edges of their ranges, disjuncts, endangered species, or other unusual features, not usually because it contains the main part of the ranges of many fairly common species. Farmers, on the other hand, are drawn to more mesic, ordinary conditions, which will support the best plant growth. This serendipitous juxtaposition, of scientific curiosity about rare species or ecosystems and agricultural propensity for mesic sites, has in New Jersey left us the Pine Barrens. While heavy use for timber products has seriously disturbed the forest, it has not had the sustained impact on the plant communities of plowing and continued agriculture.

Research has flourished there, since taxonomists travelled out from Philadelphia to botanize in the 18th century (Fairbrothers 1979). As the flora became well known and published in 1911 (Stone 1911), ecological studies were well under way, and first published in a comprehensive text in 1916 (Harshberger 1970). Research has continued on the many aspects of the flora, ecosystems, geology, soils, and other features of the Pine Barrens since, much of it presented and summarized in Forman's compendium on the Pine Barrens in 1979 (Forman 1979). Just scanning that volume and the references in it will convince anyone that the Pine Barrens have been a focus of exciting research for most of the 20th century.

But what of management? Farmers did not like the poor sandy soils, but others found abundant resources to exploit in the Pine Barrens. After all, until recently, and even today for many, land that has no clear economic use to people is waste land (Glacken 1967, preface and passim). The Pine Barrens were not waste land; they supplied iron ore and the trees with which to make charcoal to process the ore, glass sands, pitch and tar, and native plant products such as cranberries, white cedar, Lycopodium, peat, and herbs. Management is probably too strong a word to apply to the use of most of these materials; plunder would be more appropriate. But pitch pines, oaks, ericaceous shrubs, and other typical species survived this onslaught, producing the landscape we have today.

Threats to the integrity of this landscape, which would provide much more permanent damage than the preceding centuries of use, inspired preservation efforts in the 1960s and 1970s, culminating in designation of the region as the nation's first National Reserve in 1979 (Collins and Russell 1989, chapters 2 and 3). The activities leading to this designation paralleled the growth of conservation movements in the nation at large. Our current understanding of systematics and ecology indicated that the Pinelands had an intrinsic value to the biosphere in terms of its unique nature, and led to designation of the Pinelands as an International Biosphere Reserve (UNESCO 1984).[1]

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[1] The name was changed from Pine Barrens to Pinelands during the political battles leading to creation of the Pinelands National Reserve.

The managers of the Pinelands National Reserve were then left with the problem of how to maintain this value. It did not come to us unsullied by human activities, rather the opposite. To manage it wisely, one needs to know which activities will sustain and which damage the system as we think it should be: in some cases what it is today and in others what we think that it was sometime in the past.

Decisions about research and management do not occur within a cultural vacuum. Ecologists and land managers have, for example, changed their attitudes toward the role of fire many times in the past. Fire management will be used here as an example to illustrate the complex interactions between cultural values, research, and management.

Until the late 19th century, fire was viewed as both a tool in farm management and a threat to forest vegetation. Laws from the early 18th century had limited the timing and extent of fires used to clear land, in order to protect timber. Such fires still frequently escaped into the surrounding forested land. By the end of the 19th century and into the 20th, sparks from locomotives were added as a leading cause of forest fires, and because trains penetrated very widely, fires were common everywhere. Fires that escaped from land-clearing or were maliciously set in slash after logging were also major threats to forest regeneration (Hough 1882, pp. 128-207; Meier 1903, 1904, 1905). Harshberger's observation in 1916 that "forest fires have done great damage to the wild plants [of the Pine Barrens]" was typical of the attitudes toward fire at that time (Harshberger 1970, p. vi). By the late 1930s in New Jersey such changes as improved fire-suppression and decreased railroad usage contributed to a decrease in total area burned and number of fires (Forman and Boerner 1981).

In the southeastern United States long leaf pine (*Pinus palustris*) grows in open groves with a grassy understory. By 1924 in this region bobwhite quail, a very popular and income-producing game bird, were becoming scarce (Landers and Mueller 1986). Research into the decline in an important economic resource for the region suggested that a shift to larger farms, cleaner cultivation with fewer hedgerows, less fire used to clear brush, and overhunting had contributed to the decline (Stoddard 1936, Landers and Mueller 1986). Prescribed burning was initiated to improve habitat for the quail, and led to extensive research on the relationship between controlled fires and game management (Stoddard 1936). Such research on the use of fire for game management continued into the 1970s, much of it reported in the Proceedings of the Tall Timbers Fire Ecology Conferences, e.g., papers in 1970 on blue grouse and ruffed grouse and in 1972 on prairie chickens and sage grouse. In England, as well, fire was used to manage game lands (Gimingham 1970). In other words, an economic incentive led in the early days to the setting of controlled fires to manage habitats of valued wildlife.

In 1936 a controlled burning regime was established in the Pinelands to study the effect of prescribed burning (Little 1979). The goals of burning there were to reduce fuels, and thus crown fires, and to improve the pine timber, that is, a concern with improving safety and productivity. Again, the goals were related to economic return, and in this case also human well-being and protecting investments in structures that might be destroyed by wildfires.

However, by the 1960s, ecologists began to appreciate the value of fire for more general ecosystem preservation, based on observations of ecosystems where fire had been suppressed. For example, in 1969 Oberle published in Science that "forest fire suppression policy has its ecological drawbacks" (Oberle 1969) and in 1973 Tüxen published in the Proceedings of the 13th Tall Timbers Fire Ecology Conference on "the use of fire in nature conservation"

(Tüxen 1973). For the Pinelands, specifically, ecologists observed that "the importance of fire to the maintenance of the Pinelands ecosystem is undeniable. If burning practices are eliminated, the character of the Pinelands will change," understood as a change for the worse ecologically (Bartlett and others 1978). This statement in a report done for the National Park Service signalled a new emphasis on fire as a tool for reconstructing the Pinelands as they "should be." While the Comprehensive Management Plan for the Pinelands National Reserve stated more conservatively that "... many ecologists believe that the existing Pinelands landscape is in part the product of wildfires of varying intensities, including crown fires which kill the overstory" (Pinelands Commission 1980, p 69), a report on research objectives in the Pinelands two years later left no question about the beneficial effect of fire: "The New Jersey Pine Barrens is clearly a fire dependent system in which periodic fires are not only inevitable but are a natural feature of the landscape" (Good 1982, p. 11).

This new attitude, of using fire to mimic nature, must then be related to the overall goals of management in the Pinelands National Reserve, and thus management and research have needed to establish new relationships. The overall goal for natural resources in the Pinelands, as stated in the Pinelands Comprehensive Management Plan, is to "Preserve, protect and enhance the overall ecological value of the Pinelands, including its large forested areas, its essential character, and its potential to recover from disturbance" (Pinelands Commission 1980, p.193). Just to arrive at such a goal required research, based in part on the present commitment of systematists and ecologists to the rare and unique ("essential character") and conviction that disturbances such as fire were necessary for their preservation. But this goal is quite different from managing wildlife, reducing fuel, or producing timber and it requires techniques and research which are different from the more economically-motivated purposes. It has been the responsibility of the researchers to explain convincingly to the managers the rationale and consequences of the new interpretations. Further research may indicate changes in interpretations, that is, that certain kinds and distributions of fires may have very different effects, for example. The importance of such changes in interpretations must be incorporated by managers into their plans. In addition, they need to indicate to the researchers what questions they have with relation to how to use fire to reach their goals. While researchers cannot set the goals, they can provide information that is relevant to setting as well as implementing them.

Fire is one of many issues about which the interpretations have changed over the years, and thus research and management related to fire have changed as well. Both the research and the applications of the research have been closely related to contemporary societal value systems. This example illustrates the complexity of relating research and management, and the continuing readjustments that must be made.

The papers presented in this symposium have clearly demonstrated exciting frontiers of research in the Pinelands, and by extrapolation, in general, and all bear relations to managing the resources of the Pinelands. Forman and Lathrop both present landscape-scale studies. While decisions must be made at the local scale, these decisions must be set in the context of the regional, or landscape, scale. The models presented by Forman provide a theoretical way of testing the consequences of patterns of landscape change, which are generalized across many kinds of landscapes (Franklin and Forman 1987). To relate these models to the management decisions requires making them responsive to specific kinds of disturbances in the Pinelands, and local patterns of disturbance, such as "nibbling at the edges." They provide a framework in which to ask questions about many otherwise unexpected consequences of management decisions before these decisions are implemented. The concept of sustainability can provide a framework in which to set the goals for management of the resource.

Lathrop's use of remote sensing provides a way of analyzing the elements of natural landscapes at different scales and monitoring changes over time. The importance of consistency in collecting data, so that they will be comparable over time, is critical. For example, the pixel size of the image determines the spatial scale of activities that can be detected. Remote images can provide more details of spatial diversity than can be detected visually in a photograph, so that, for example, cedar swamps which appear on photographs to be continuous corridors, may appear as discrete patches in the remote images. Such detail provides information that can be used in management decisions regarding preservation of cedar swamps, depending on the importance of the continuity of the corridors. It is critical that those interpreting, and planning, the remote images interact with those making management decisions, so that the scales of the information provided and needed coincide.

Research on major components of the ecosystem, oaks (*Quercus* spp.) and mosses, as reported by Fairbrothers and Karlin provides information on the scale of individual organisms and species that leads to the broader patterns recognized by Forman and Lathrop. These two taxa, which have suffered from unmerited neglect relative to pines (*Pinus* spp., especially *P. rigida*), are integral parts of the unique vegetation of the Pinelands. Because the diversity of the oaks is due as much to intra- as to inter-population variation their contribution to the diversity of the plant communities and the ability to recover from disturbance is much greater than might appear from overall vegetation patterns. This diversity is reflected also in a major pattern of recovery from disturbance by sprouting from lignotubers. Both of these characteristics of oaks need to be integrated into management of the Pinelands. It is interesting to note that in another pitch pine (*P. rigida*) community, the Albany (New York) "Pine Bush," it is the scrub oak (*Quercus ilicifolia*) that is most characteristic of the vegetation (Zaremba et al. 1990).

The contribution of the mosses to the "essential character" of the Pinelands is unique. The lack of diversity of the group as a whole stands in contrast with the extremely high diversity of the one genus, *Sphagnum*. The closer affinity with the northern than with the southern moss flora, as contrasted with the more southerly vascular plant affinity, suggests that mosses are responding to different elements of the ecosystem and/or landscape as a whole. To approach the goal of maintaining the "essential character" of the Pinelands, the reasons for this difference should be further explored. In addition, the reactions of *Sphagnum* in responding to disturbance are clearly important. Both of these are compelling reasons for management to pay more attention to updating the moss flora and ecology of the Pinelands.

Finally, we need to be reminded of the importance of the human element in the Pinelands, both in the present and the past. The Pinelands is not just a natural region, but it also has a rich cultural heritage. While many associate it with the "Pineys," the history of other cultural and ethnic groups contribute to this heritage. Research on such individuals as James Still adds immeasurably to our appreciation of the kinds of lives people lived in the past, and ways in which outstanding individuals could rise above their humble beginnings. Management of the Pinelands should include interpretation of communities and individuals who contributed to the unique cultural heritage of the region.

The actions required to manage a landscape or anything else are never clearcut. The ecologists cannot say with certainty that if you burn a specific site once every 10 years with a crown fire you will get the desired plant and animal communities. The actual decisions are subjective. A quotation from Paul Sears, written in 1935 in *Deserts on the March*, makes this point more clearly:

> Science has the power to illuminate, but not to solve, the deeper problems of mankind. For always after knowledge come choice and action, both of them intensely personal and individual. Science is like those services which supply a battle commander with information of the enemy and technical advice on physical problems, but which cannot relieve him of the task of decision. For the last his own intuition, perhaps even the toss of a coin, must serve. The inescapable character of this dilemma is recognized in the old military maxim that action on an inferior decision is far better than no action at all. (Sears 1988, p. 219)

The manager trying to use the results of research is in the position of the military commander described by Sears. He receives information and technical details from the researchers, and has overall goals to achieve, but how he uses the information to reach the goals has to be a subjective decision. Sears does not discuss here the importance of setting the goals, but that is clearly a part of the decision-making process. Research presented at this symposium can be incorporated into management strategies in the Pinelands National Reserve, and I think that all of it relates to the objectives for which the Reserve was set up. The specific applications and the encouragement of future research will depend on effective communication between those making the decisions and those doing the research.

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Bartonia No. 58: 29-68, 1994

Taxonomy of *Scirpus*, *Trichophorum*, and *Schoenoplectus* (Cyperaceae) in Virginia

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In the last 30 years, embryological, anatomical, and cladistical studies in the subfamily Cyperoideae have lent supporting evidence to the premise that *Scirpus* sensu lato is a heterogeneous group. Van der Veken (1965) studied embryo morphology of species in the subfamily Cyperoideae. He classified the mature embryos into six types. All six of these types were found to be represented in *Scirpus* sensu lato. Van der Veken felt that several genera could have the same embryo type, but no genus should have more than one embryo type represented in it. The embryos of Virginia *Scirpus* sensu lato fall into three of these types (Table 1). This indicates that Virginia *Scirpus* sensu lato should be represented at least by three different genera.

Studying anatomical and morphological characteristics as well as habitat types of natural groups occurring in *Scirpus* sensu lato, Schuyler (1971a, 1971b, 1972b) developed a preliminary basis for taxonomically delineating these groups. The results of his studies are incorporated into Table 2 which, in addition, includes a summary of other significant characters that these groups have in common or separate them from each other. *Schoenoplectus* can be distinguished from *Scirpus* sensu stricto and *Trichophorum* by differences in embryo type, leaf anatomy, inflorescence type, size and epidermal structure of achenes, style morphology, anther morphology, and habitat. *Trichophorum* can be distinguished from *Scirpus* sensu stricto by differences in embryo type, leaf anatomy, inflorescence type, epidermal structure of achenes, and habitat.

Cladistical analysis of the subfamily Cyperoideae by Goetghebeur (1986) indicates that *Schoenoplectus* is separate from the tribe Scirpeae and belongs in the tribe Fuireneae, which also includes the genera *Actinoscirpus*, *Pseudoschoenus*, and *Fuirena*. This conclusion is based primarily on embryo-type and morphology of the perianth bristles. In his cladistical analysis of the tribe Fuireneae, Goetghebeur (1986) recognizes the genus *Bolboschoenus* as have other recent workers (e.g., Raynal 1973; Oteng-Yeboah 1974; Wilson 1981; and Koyama 1985, 1990), however, he seems to dismiss the similarities in embryo shape, floral morphology (anthers, styles, perianth bristles, and achenes), leaf anatomy, inflorescence, and habitat between *Schoenoplectus* and *Bolboschoenus*. Goetghebeur & Simpson (1991) separate both *Bolboschoenus* and the monotypic Asian genus *Actinoscirpus* from *Schoenoplectus* primarily on the basis of well-developed leaf blades and involucral bracts, and terminal inflorescence of *Bolboschoenus* and *Actinoscirpus* vs. reduced leaf blades and involucral bracts, and pseudolateral inflorescence of *Schoenoplectus*. However, these characters are not consistent within *Schoenoplectus* and *Bolboschoenus*. There are a number of species in *Schoenoplectus* (e.g., *Sch. etuberculatus*, *Sch. subterminalis*, *Sch. torreyi*, and

TABLE 1. Embryo types of Virginia *Scirpus* sensu lato and their classification. From Van der Veken (1965) and Wilson (1981).

	CAREX-TYPE	FIMBRISTYLIS-TYPE	SCHOENOPLECTUS-TYPE (Scirpus embryo of Van der Veken)
EMBRYO SHAPE	top-shaped	top-shaped	mushroom-shaped
COLEOPTYLE (final position)	lateral	basal	basal
RADICLE (final position)	basal	lateral	lateral
FIRST LEAF (orientation of germination pore relative to first leaf)	perpendicular	perpendicular	parallel
GENERA IN VIRGINIA	TRICHOPHORUM	SCIRPUS	SCHOENOPLECTUS

Sch. pungens) that have well developed leaves, although they are confined primarily to the lower portion of the culm. Schuyler (1971a) found anatomical evidence that the well-developed leaf blades of tuberous bulrushes (*Bolboschoenus*) were homologous to those found in one species of *Schoenoplectus* (*Sch. americanus*). The leaf blades of this species and those of *Bolboschoenus* have chlorenchyma occurring in about equal abundance on both the adaxial and abaxial sides of the leaf blade, as well as stomates occurring in equal abundance in the adaxial and abaxial epidermis. In further anatomical studies done on *Schoenoplectus*, Schuyler (1972b) found two other species (*Sch. etuberculatus* and *Sch. subterminalis*) that have chlorenchyma on both the adaxial and abaxial sides of the leaf blade.

Although the inflorescences of *Schoenoplectus* (as circumscribed by Goetghebeur and Simpson 1991) are primarily pseudolateral and subtended by an erect bract appearing as a continuation of the culm, there are species in *Schoenoplectus* (particularly those that have elongate inflorescence rays) that have 1-3 additional inflorescence bracts subtending the inflorescence (e.g., *Sch. validus*, *Sch. acutus*, *Sch. californicus*, *Sch. torreyi*, and *Sch. etuberculatus*). In *Bolboschoenus*, the lowest involucral bract is leaf-like above the inflorescence, but the inflorescence typically appears pseudolateral at anthesis and in reduced forms. Only at maturity do the elongate involucral bracts spread out, giving the inflorescence a terminal appearance. Furthermore, the Asian species *Bolboschoenus planiculmis* has a pseudolateral inflorescence, the lowest involucral bract appearing as a continuation of the culm as in *Schoenoplectus*, but the floral morphology is that of *Bolboschoenus*. Therefore, because of the similarities between embryo shape, leaf anatomy, floral morphology, and inflorescence between *Schoenoplectus* and *Bolboschoenus*, I cannot justify the separation of these plants into distinct genera.

This study examines plants of the genus *Scirpus* sensu lato that occur in Virginia. *Scirpus* sensu lato has been treated in North Carolina (Cappell 1954) and species mapped by county in Virginia (Harvill et al. 1992), but no formal treatment has been made for Virginia. Notes and studies on species of *Scirpus* sensu lato that occur in Virginia are scattered in the literature and many species have been poorly defined and disregarded by workers in Virginia. A clarification of the taxonomic position of species of *Scirpus* sensu lato is thus needed for Virginia.

TABLE 2. Summary of the main characteristics of the three segregate genera of *Scirpus* sensu lato in Virginia.

TRICHOPHORUM	SCIRPUS	SCHOENOPLECTUS
1. Carex embryo-type	Fimbristylis embryo-type	Schoenoplectus embryo-type
2. Leaf blades well developed or reduced (keel-shaped or crescentform-shaped in cross section), with bulliform cells and sclerenchyma girders associated with at least some of the vascular bundles	Leaf blades well-developed (keel-shaped in cross section) with chlorenchyma cells more developed on adaxial side than on abaxial side; stomates primarily restricted to abaxial epidermis	Leaves bladeless or with well-developed, elongate blades (crescentform or keel-shaped in cross section), chlorenchyma cells developed only below air cavities (on abaxial side of leaf) or equally developed on both abaxial and adaxial sides; stomates generally present in both abaxial and adaxial epidermis
3. Inflorescence usually of a single termnal spikelet, the involucral bract scale-like	Infloresence generally much-branched, terminal, subtended by a leafy involucre; spikelets small, numerous	Inflorescence compact or few-branched, pseudolateral, with an involucre of 1 (-3) bracts, or involucre leafy, the infloresence appearing terminal at maturity
4. Achenes with non-wavy inner cell walls, lacking buttresses and having apical nodules which give the achene a minutely papillate texture	Achenes with wavy inner cell walls, buttresses and apical nodules which give the achene a minutely papillate texture, mostly less than 1.5 mm long	Achenes smooth, pitted or rugulose, epidermal cell structure diverse, mostly more than 1.5 mm long
5. Styles subulate, the branches with minute rounded protrusions (seen under high magnification)	Styles subulate, the branches with minute rounded protrusions (seen under high magnification)	Styles sub-flattened to strap-like, the branches scaly or furrowed, glabrous or with scattered hairs
6. Anthers apiculate at apex	Anthers apiculate at apex	Anthers with a barbed or prickly appendage at apex
7. Grow in dry to moist substrates primarily in upland forests and deciduous woods	Grow in seasonally wet substrates such as swamps, marshes, shallow pools; culm bases not submerged or only partially so	Grow primarily in water along large river systems, and in estuaries, lakes and ponds; culm bases usually submerged

This study endeavors to provide a concise, comprehensive treatment of the species of *Scirpus* sensu lato that occur in Virginia. With the increasing concern over our dwindling natural resources in Virginia, particularly wetland areas in which species of *Scirpus* sensu lato play an important role in the ecology of these habitats, it is important that a treatment be made available to workers doing field work in Virginia. The resulting treatment will facilitate the identification of species as well as clarify taxonomically the classification of these plants.

The treatment contains: (1) a key to the genera of *Scirpus* sensu lato in Virginia and keys to species in each genera; (2) a SEM photomicrograph of the fruit (achene) of each species; (3) a drawing of a representative species in each genus and selected species as an aid, along with the dichotomous keys, to identifying closely related species, and (4) a detailed description of each species which includes flowering and fruiting times, distribution, habitat, distinguishing features, and in some species, clarification of nomenclatural changes or differences between related species are discussed.

METHODS

Studies of Virginia *Scirpus* sensu lato were based on herbarium material and my own personal collections. Morphological characteristics of each species were examined. These included habit, rootstock, leaves, culms, inflorescence, flowers, and fruit. A taxonomic treatment was then prepared based on morphological characteristics as well as evidence from embryological, anatomical, and cladistical studies from recent literature. Specimens were examined from the following herbaria: Longwood College, Farmville, Virginia (FARM); George Mason University, Fairfax, Virginia (GMUF); New York Botanical Garden, Bronx, New York (NY); Academy of Natural Sciences, Philadelphia, Pennsylvania (PH); United States National Herbarium, Washington, D.C. (US); Virginia Polytechnic Institute and State University, Blacksburg, Virginia (VPI); and The College of William and Mary, Williamsburg, Virginia (WILLI). Searches for chromosome counts recorded in the literature were made for each species. These are summarized in Table 3. Specimens cited are available upon request. All specimens collected by the author are deposited at GMUF. This study is based on the author's M.S. thesis.

MORPHOLOGICAL COMPARISON OF THE THREE GENERA

RHIZOMES. The rhizomes of *Scirpus* are typically short, hardened and knotty, and frequently bear two or more culms. In *Trichophorum* they are small, short and knotty, and bear dense tufts of leaves and culms, or in some species, they are elongate and slender and bear culms singly along the rhizome. In *Schoenoplectus*, they are elongate and bear culms singly along the rhizome. Culms may either arise spaced at intervals along the rhizome as in *Sch. pungens* and *Sch. americanus* or in a row as in *Sch. validus* and *Sch. acutus*. A few closely related species of *Schoenoplectus* (e.g., *Sch. robustus*, *Sch. fluviatilis*, and *Sch. novae-angliae*) have hard, tuberous enlargements along the rhizomes below culm bases. These may function either as both supporting structures in the flooded habitat they typically grow in or as tubers for vegetative reproduction.

CULMS. The culms of *Scirpus* are trigonous or obtusely trigonous, stout, and are rarely less than 5 dm tall. Mature culms of *Scirpus divaricatus* frequently proliferate from the leaf axils, the reclining culms eventually touching the ground and rooting. The culms of *Trichophorum* are trigonous or terete, slender, and typically less than 4 dm tall. In *Schoenoplectus* they are terete or trigonous, stout, and usually more than 5 dm tall. The culms of many species of *Schoenoplectus* (e.g., *Sch. validus*, *Sch. acutus*, *Sch. americanus*, and *Sch. pungens*) develop air cavities, presumably as an adaptation to aquatic environments.

LEAVES. Leaves of *Scirpus* are both basal and cauline. The sheath is usually short-ligulate at the adaxial junction of sheath and blade and has a membranous inner band with a U-shaped or truncate to convex orifice which may split as the plant increases in circumference. The blades are typically flattened and have numerous veins with the midvein being most prominent. The margins and the midvein beneath are usually scabrous. Anatomically, the flattened, keeled, V-shaped blades of *Scirpus* (as seen in cross section) have chlorenchyma more developed on the adaxial side of the blade than on the abaxial side. Stomates are primarily restricted to the abaxial epidermis (Schuyler 1971a). The leaves of *Trichophorum* are typically basal, bladeless, or the uppermost blade-bearing. Sheaths bearing blades are short-ligulate adaxially at junction of sheath and blade and have a scarious inner band. Blades are typically subflattened to flattened, narrow, usually less than 2 mm wide,

TABLE 3. Haploid chromosome numbers of Virginia *Scirpus* sensu lato.

TAXON	MEIOTIC UNITS (n)	REFERENCE
Scirpus divaricatus	14	Schuyler 1963, 1967a
S. polyphyllus	29	Schuyler 1967a, 1975b
S. expansus	32	Schuyler 1967a
S. ancistrochaetus	27	Schuyler 1963, 1967a
S. georgianus	24; 25, 26, 27	Harriman 1981; Schuyler 1967a, 1975b
S. flaccidifolius	27	Schuyler 1967a
S. atrovirens	25; 28; 31	Harriman 1981; Schuyler 1963, 1975b, A. & D. Löve 1981; Harriman 1981
S. hattorianus	28	Schuyler 1967a
S. cyperinus	30, 32; 33; 35	Harriman 1981; Hicks 1928, Schuyler 1967a; Harriman 1981
S. lineatus	18	Schuyler 1963, 1967a
S. pendulus	20	Schuyler 1963, 1967a, Harriman 1981
Trichophorum planifolium	46	Schuyler 1971a
Schoenoplectus smithii	20	Schuyler 1972a
Sch. purshianus	19	Schuyler 1972a
Sch. subterminalis	37	Schuyler 1975b
Sch. torreyi	21; 35	A. & D. Löve 1981; Schuyler 1975b
Sch. americanus	39	Hicks 1928, Schuyler 1975b
Sch. pungens	37; 38; 39	Harriman 1981; Hicks 1928; Schuyler 1975b
Sch. validus	21	Hicks 1928, Schuyler 1975b, A. & D. Löve 1981, Harriman 1981
Sch. acutus	18; 19; 21	Harriman 1981; Schuyler 1975b; A. & D. Löve 1981
Sch. etuberculatus	—	—
Sch. fluviatilis	47; 52; 55	Harriman 1981; A. & D. Löve 1981; Hicks 1928
Sch. robustus	53, 54, 55	Hicks 1928
Sch. novae-angliae	—	—

keel-shaped or crescentform in cross section and typically have sclerenchyma girders either between the vascular bundles and the abaxial epidermis or between the vascular bundles and epidermis on both abaxial and adaxial sides of the blade. Bulliform cells are also present in some species (Schuyler 1971a). In some species of *Schoenoplectus* (e.g., *Sch. purshianus* and *Sch. validus*) the leaves are reduced to short protrusions from the bladeless sheaths. In other species (e.g., *Sch. americanus*, *Sch. pungens*, *Sch. torreyi*, *Sch. etuberculatus*, and *Sch. subterminalis*), they have short to elongate blades borne only near the base or they can be both basal and cauline. The sheaths of some species of *Schoenoplectus* are eligulate while others bear a short ligule at the adaxial junction of sheath and blade. The inner band is membranous in some species and has a V-shaped to truncate orifice that may split with age, while in others it is firm and has a concave to convex scarious-tipped orifice. Blades of *Schoenoplectus* vary greatly in shape as seen in cross section. They may be dorsally flattened at base becoming laterally flattened to sub-trigonous near the apex as in *Sch. pungens* and *Sch. americanus*, triangular-channeled as in *Sch. etuberculatus* and *Sch. torreyi*, crescentform-capillary as in *Sch. subterminalis*, or V-shaped to dorsally flattened with a prominent midvein and indistinct lateral veins usually scabrous beneath as in *Sch. robustus*, *Sch. fluviatilis*, and *Sch. novae-angliae*.

Anatomically, chlorenchyma is generally restricted to the abaxial side of the blade below the air cavities, but in *Schoenoplectus americanus*, *Sch. etuberculatus*, *Sch. subterminalis*, *Sch. robustus*, *Sch. fluviatilis*, and *Sch. novae-angliae*, chlorenchyma is on both abaxial and adaxial sides of the blade, although in *Sch. etuberculatus* and *Sch. subterminalis*, the adaxial chlorenchyma is not as well developed as the abaxial chlorenchyma. The margins of the blades of *Sch. americanus* have chlorenchyma equally developed adaxially and abaxially. Frequently, thin diaphragms develop across air cavities. These may serve a particular function in regards to adaptation to an aquatic environment (Schuyler 1971a, 1972b). Stomates are present in both the adaxial and abaxial epidermis of some species (e.g., *Sch. americanus*, *Sch. etuberculatus*, *Sch. robustus*, *Sch. fluviatilis*, and *Sch. novae-angliae*). In other species, e.g., *Sch. torreyi* and *Sch. subterminalis*, stomates are restricted to the abaxial epidermis and only a portion of the adaxial epidermis near the margin of the blade (Schuyler 1971a, 1972b).

In marsh habitats along tidal rivers where species of *Schoenoplectus* co-occur, I have observed the species with tubers, leaves with well-developed blades which extend above the mid portion of the culm, and leaf-like involucral bracts (e.g., *Sch. novae-angliae* and *Sch. robustus*) growing in the more densely vegetated portions of the marsh, back from open water, while those species with reduced leaves (e.g., *Sch. pungens* and *Sch. validus*) tend to be concentrated on the outer edges of the marsh (facing open water) where the density of vegetation is much less. In portions of the marsh where vegetation is dense, there should be increased competition for resources, space, and sunlight. Those plants with elongate leaf blades and involucral bracts, as well as starch-storing tubers would have an advantage over those having reduced leaves and involucral bracts (having only the stem and 1-few basal leaves capable of photosynthetic activity) and non-tuberous rhizomes. Schuyler (1971a) suggested that the well-developed leaf blades of some species of *Schoenoplectus* may represent an evolutionary modification of other species in this genus which have reduced leaf blades.

INFLORESCENCE. Inflorescences of *Scirpus* are typically broad, with an umbelliform or corymbose terminal panicle of many rays. The rays are usually elongate, stiff, ascending to divaricate as in species characteristic of *S. georgianus*, or flexuous and pendulous as in species characteristic of *S. cyperinus*. The rays are terete and ribbed and may be smooth, or upwardly scabrous in some species. Spikelets are borne singly at ray tips, or in glomerules of 2-many. Involucral bracts are typically leaf-like with well-developed blades and in some species greatly exceed the inflorescence, e.g., as in *S. cyperinus*, or are reduced and shorter than the inflorescence as in *S. pendulus*. *Trichophorum* typically has a single spikelet at the summit of the culm, subtended at the base by a single, scale-like involucral bract which is thickened at the apex. Inflorescences of *Schoenoplectus* are typically a pseudolateral corymb or head, the lowest involucral bract appearing as a continuation of the culm. The pseudolateral appearance of the inflorescence in some species is less pronounced, particularly in those species having elongate, flattened, leaf-like involucral bracts. Species such as *Sch. robustus* or *Sch. novae-angliae* have a number of well-developed, elongate, involucral bracts subtending the inflorescence that at maturity spread out, giving the inflorescence a terminal appearance. However, the lowest involucral bract is usually longer than those above, and at anthesis is erect, giving the inflorescence a pseudolateral appearance. In some species of *Schoenoplectus*, particularly those that have somewhat open, anthelate inflorescences (e.g., *Sch. validus*, *Sch. acutus*, and the western North American species *Sch. californicus*), the lowest involucral bract is erect and culm-like, but there is also present one or two additional small involucral bracts above.

Inflorescence rays of *Schoenoplectus* are smooth, angled, terete or somewhat flattened, either elongate as in *Sch. validus* and *Sch. fluviatilis*, or reduced and inconspicuous as in *Sch. americanus* and *Sch. pungens*. Spikelets are borne singly at ray tips or in glomerules of 2-many. Involucral bracts are usually 1 (-3) in those species with the lowest bract appearing as a continuation of the culm, or 3-6 in those species such as *Sch. fluviatilis* which have elongate, leaf-like involucral bracts.

SPIKELETS. The spikelets of *Scirpus*, *Trichophorum*, and *Schoenoplectus* consist of spirally imbricated scales that each subtend a flower. In *Scirpus*, the spikelets are generally ovoid and range from 2-6 (-8) mm long and 1-3 mm wide, but in some species (e.g., *S. divaricatus*, *S. lineatus*, and *S. pendulus*) they are ovoid to lance-ovoid or linear-cylindric and elongate up to 1.5 cm. In *Trichophorum* the spikelets are ovoid to ovoid-ellipsoidal, generally small, and range from 3-8 mm long and 2-4 mm wide. Spikelets of *Schoenoplectus* are generally ovoid to oblong-ovoid and range in size from 0.4-6 cm long and 3-12 mm wide. In *Sch. novae-angliae* and *Sch. robustus* f. *protrusus*, the spikelets are elongate and range from 2-6 cm long.

FLOWERS. The typical flower of *Scirpus*, *Trichophorum*, and *Schoenoplectus* is perfect. The ovary is typically 3-angled and crowned with a 3-branched, caducous style continuous with the ovary, but in *Schoenoplectus smithii* and *Sch. purshianus*, the ovary is 2-sided and crowned with a 2-branched style. Style branches of *Scirpus* and *Trichophorum* are subulate and have minute, rounded protrusions covering them. Style branches of *Schoenoplectus* are furrowed or minutely scaly and sometimes have ascending to divergent hairs. Bristles are typically six in all three genera, but in some species and forms they are abortive (e.g., *Scirpus georgianus* and *Schoenoplectus smithii* f. *smithii*). Bristles are retrorsely barbed in many species, but in *Trichophorum* they have spinulose hairs, or vestiture may be lacking altogether as in *Scirpus pendulus*. Stamens are typically 3, but 1 or 2 may be abortive in some individuals which only have 1 or 2 functional. Anthers are narrowly oblong and basifixed, and the thecae are parallel and longitudinally dehiscent. The apex may be apiculate as in *Scirpus* and *Trichophorum* or have a glabrous, barbed or prickly, triangular to acute appendage as in *Schoenoplectus*. Pollen of all three genera are typically uniaperturate, psilate, binucleate or trinucleate, subspheroidal in polar view, and triangular

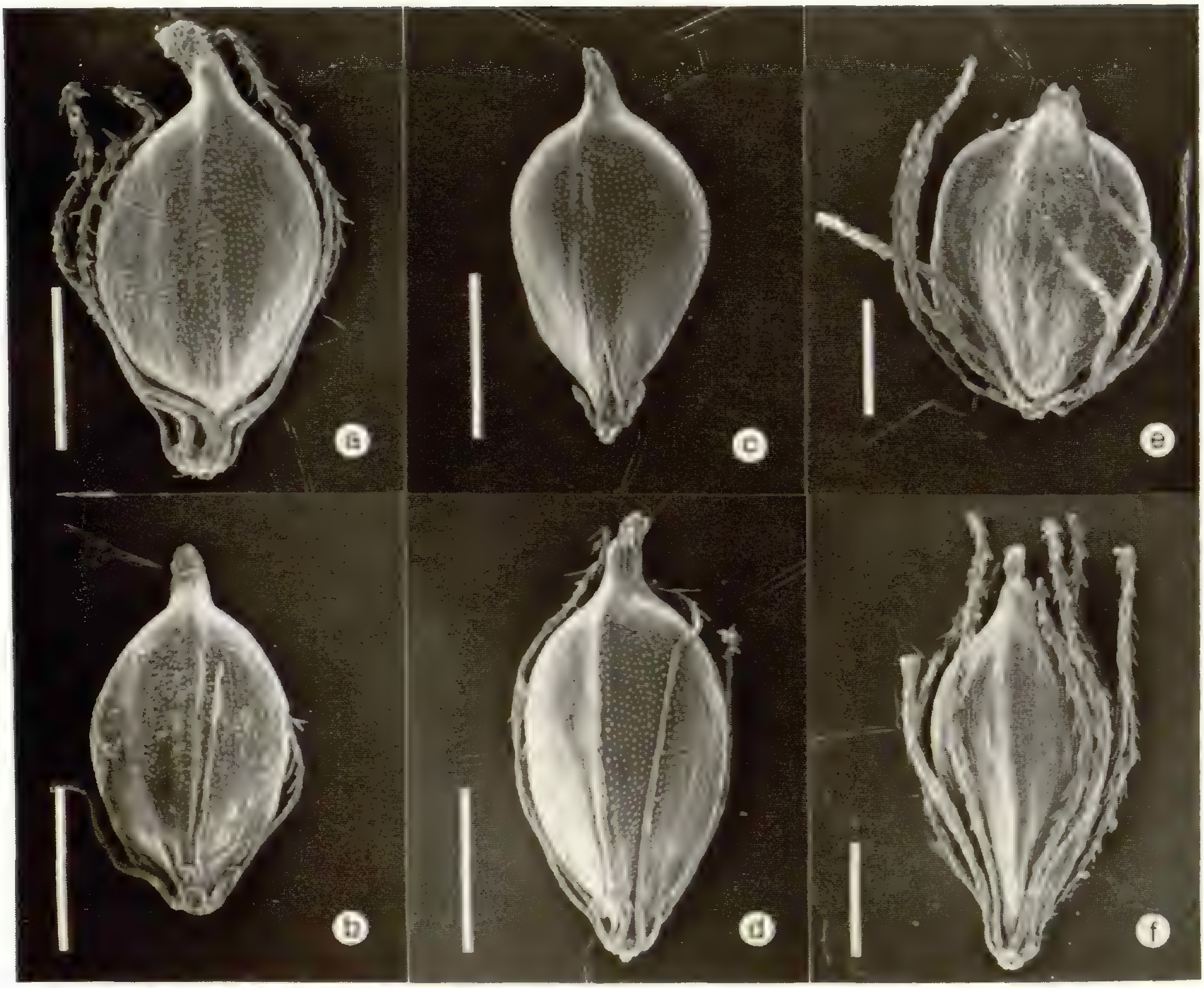


FIG. 1. Achenes of *Scirpus*, bar = 400 µm. (a) *S. atrovirens* (Harvill 14877, FARM, PH). (b) *S. hattorianus* (Allard 11493, US). (c) *S. georgianus* (Harvill 28935, FARM, PH). (d) *S. flaccidifolius* (Fernald & Long 10140, PH, US). (e) *S. expansus* (Small s.n., NY, PH, US). (f) *S. ancistrochaetus* (Wieboldt et al. 5595, PH).

to obovoidal in equatorial view (Tucker 1989).

ACHENES. Achenes of *Scirpus* (Figs. 1a-1f and 2a, 2c-2e) are typically plano-convex or subtrigonous as in *S. atrovirens*, but may be sharply trigonous as in *S. divaricatus*. They are usually less than 1.5 mm long and have thin, delicate pericarps (Schuyler 1971a). The surface is typically minutely papillate, or faintly so. Each epidermal cell has a convex body and apical nodules which give the surface a papillate texture (as seen under high magnification). The inner cell walls have a wavy configuration. These undulating walls may be high in some species or low in others. Buttresses frequently occur between the cell walls and the achene body. These vary in size and may be well developed in some species or very small in others. As mentioned previously, cells have a conical or convex body with a single apical nodule or a series of compactly arranged apical nodules (Schuyler 1971a, 1971b). Achenes of *Trichophorum* (Fig. 2b) are typically trigonous. The surface is minutely papillate (as seen under high magnification). Achene epidermal cells have a conical body, apical nodules, and non-wavy inner cell walls that lack ridge-like buttresses between the lateral cell walls and the body (Schuyler 1971a, 1971b). Achenes of *Schoenoplectus* (Figs. 3 and 4) may be trigonous as in *Sch. torreyi* or *Sch. fluviatilis*, plano-convex as in *Sch.*

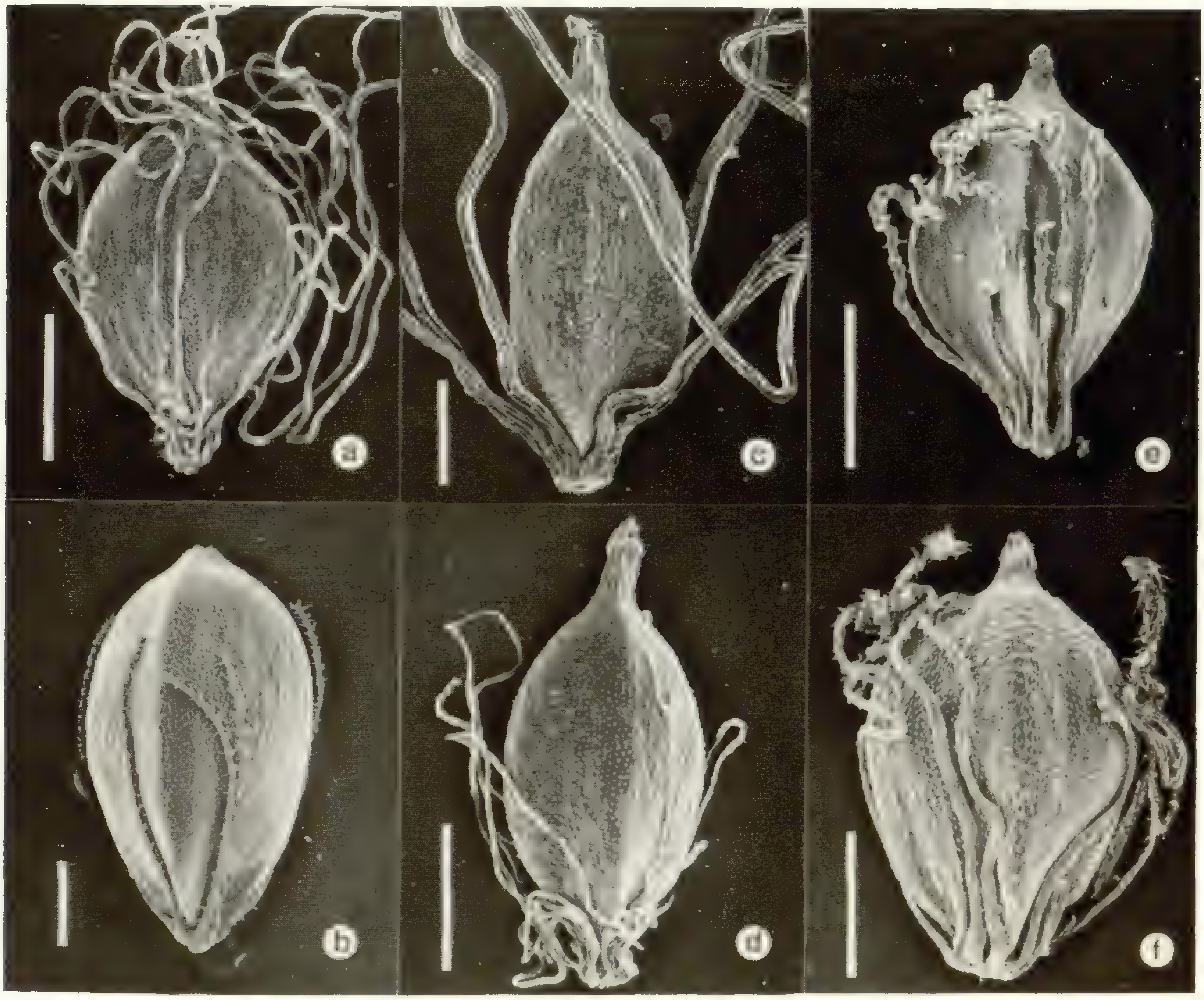


FIG. 2. Achenes of *Scirpus* s.s. and *Trichophorum*, bar = 400μm except for *S. cyperinus* (c) which = 200μm. (a) *S. pendulus* (Harvill 14378, FARM, PH). (b) *T. planifolium* (Allard 6537, US). (c) *S. cyperinus* (Egler 40-257, US). (d) *S. lineatus* (Fernald & Moore 15045, NY,PH,US). (e) *S. divaricatus* (Kearney 1633, US). (f) *S. polyphyllus* (Fosberg 43092, US).

pungens or *Sch. novae-angliae*, or somewhat lenticular as in *Sch. purshianus*. They are usually more than 1.5 mm long, typically are smooth with comparitively hard walls, and at maturity are dark brown to blackish. In some species, e.g., *Schoenoplectus purshianus*, they may be shallowly pitted, or in some species occurring out of the range of this treatment, they may be transversely rugulose. Achene epidermal cell structure is very diverse among species in this group. Some species have a great deal of internal differentiation, i.e. nodular peaks, buttresses, etc., while others have very little. In some species, particularly the smaller annuals, epidermal cells are vertically elongate and have little internal differentiation. Others, such as *Schoenoplectus validus*, have shorter cells and a great deal of internal differentiation (Schuyler 1971a, 1971b).

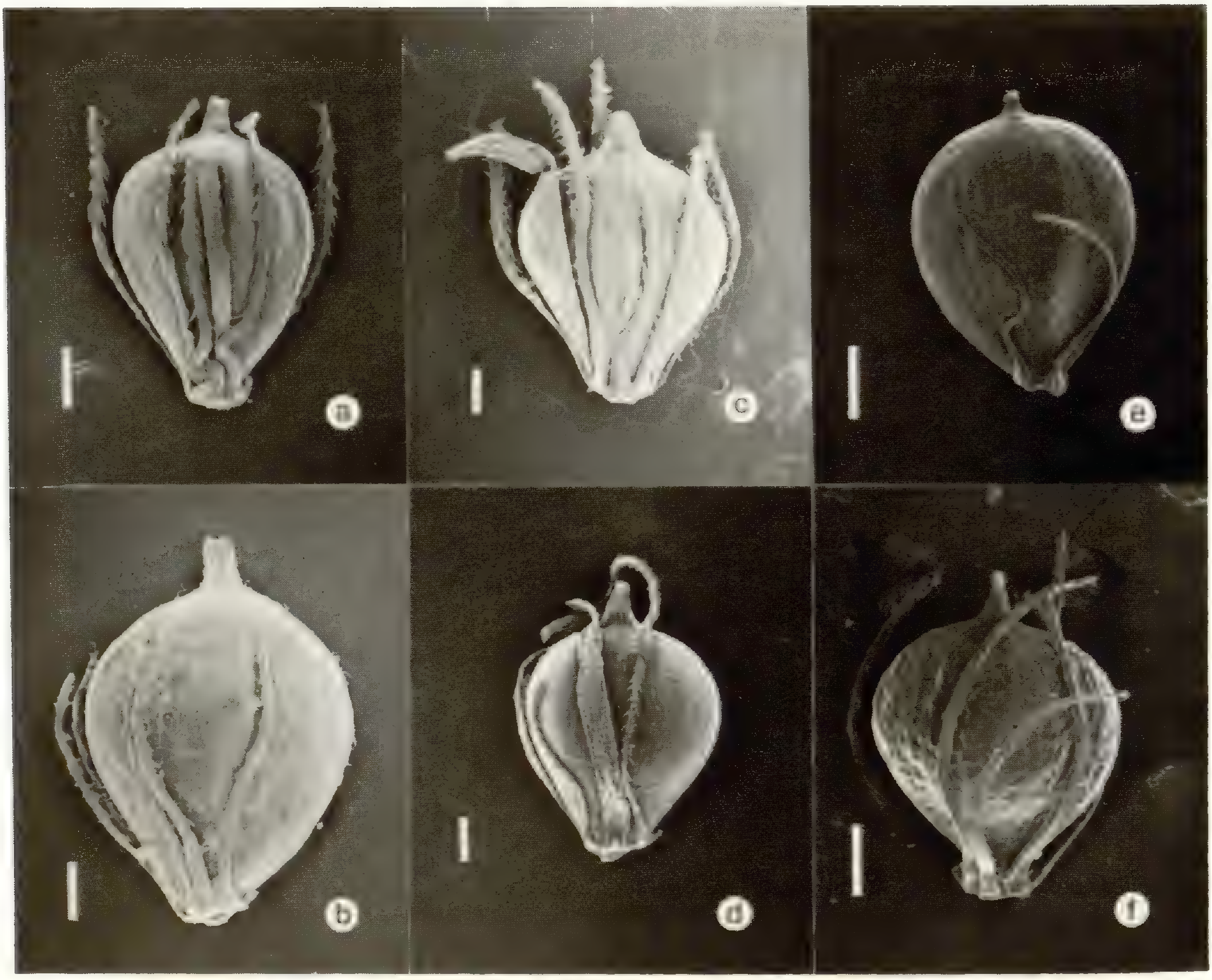


FIG. 3. Achenes of *Schoenoplectus* s.l., bar = 400µm. (a) *Sch. validus* (A. Ruth s.n., US). (b) *Sch. acutus* (Hotchkiss & Ekvall 43092, US). (c) *Sch. americanus* (Fernald & Long 3777, PH). (d) *Sch. pungens* (McCarthy s.n., US). (e) *Sch. smithii* (Shull 204, US). (f) *Sch. purshianus* (Harvill 20394, FARM,PH).

TAXONOMIC TREATMENT

Key to Genera

A. Involucral bract one, scale-like; spikelet solitary, terminal. Plants (in Virginia) of dry upland forests and deciduous woods
. . . . 2. **Trichophorum**
A. Involucral bracts 1 to many, not scale-like; spikelets numerous, rarely solitary. Plants growing in water along rivers, estuaries, pond margins or in seasonally wet substrates such as swamps, marshes, or shallow pools (B)
  B. Involucral bracts (1-) 2-6, leaf-like, flattened; culms leafy (C)
    C. Spikelets less than 1 cm long; achenes usually less than 1.5 mm long
    . . . . 1. **Scirpus**
    C. Spikelets more than 1 cm long; achenes more than 1.5 mm long
    . . . . 3. **Schoenoplectus**
  B. Involucral bracts 1 (-3), the lowest elongate, appearing as a continuation of the culm, terete or triangular; culms naked or leafy only towards base
  . . . . 3. **Schoenoplectus**

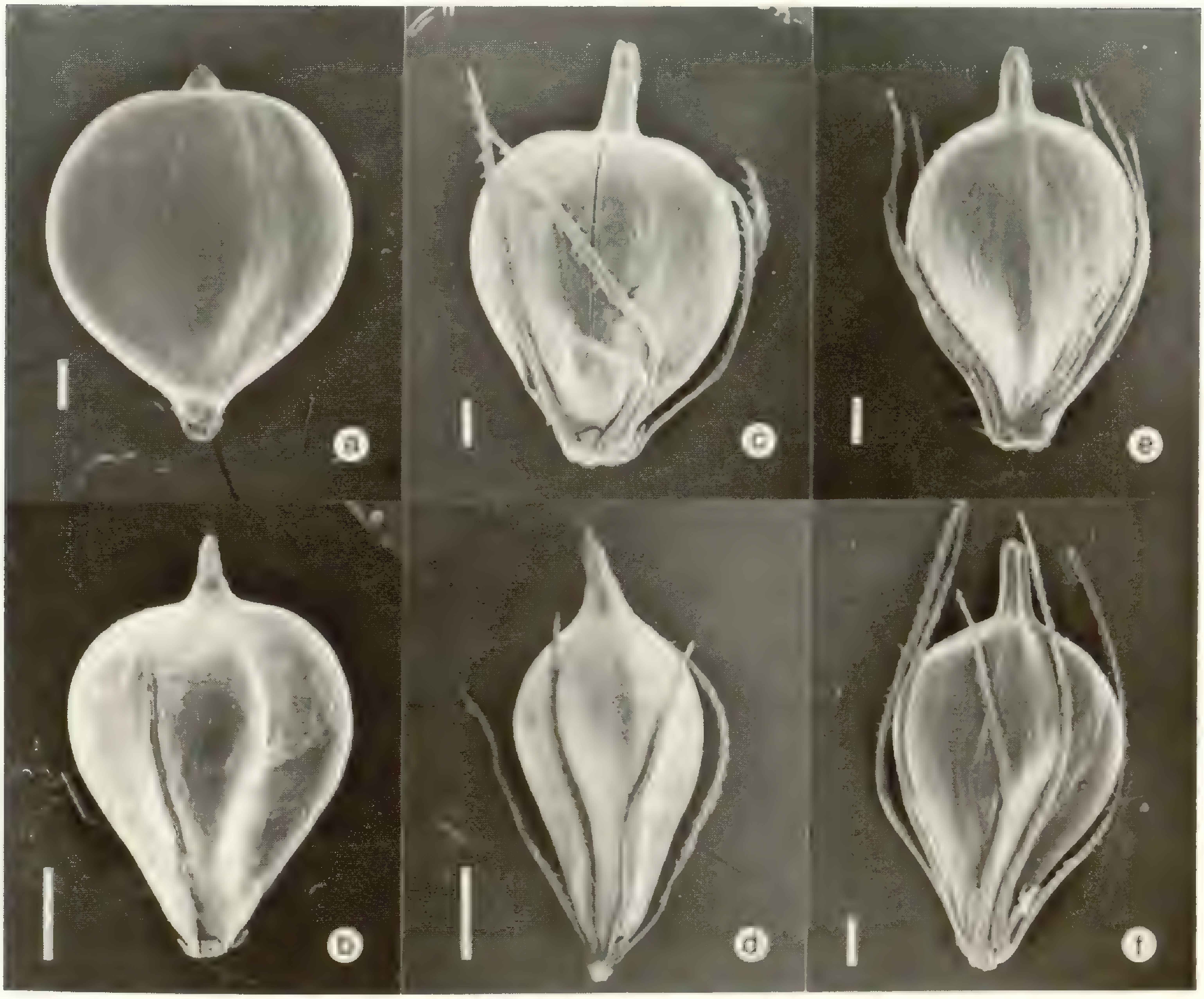


FIG. 4. Achenes of *Schoenoplectus* s.l., bar = 400µm except for *Sch. fluviatilis* (d) and *Sch novae-angliae* (b) which = 1 mm. (a) *Sch. robustus* (L. B. Smith 5523, US). (b) *Sch. novae-angliae* (Hotchkiss & Uhler 7143, US). (c) *Sch. etuberculatus* (Canby s.n., US). (d) *Sch. fluviatilis* (Ward s.n., US). (e) *Sch. subterminalis* (Nelson 1935, US). (f) *Sch. torreyi* (Harvill 26411, FARM,GMUF,PH).

1. **Scirpus** L., Sp. Pl. 47. 1753.
Type species: *S. sylvaticus* L.

Rhizomatous perennials with fibrous roots. Culms 0.3-2 m tall, trigonous. Leaves well-developed, sheathed at base, the sheaths glabrous, with a hyaline, purple-dotted, U-shaped (or convex to truncate on upper culm leaves) orifice. Inflorescences terminal and occasionally in upper leaf axils, umbel-like corymbs subtended by (1-) 2-6 leaf-like involucral bracts, many-rayed, the rays subtended by small bracts enclosed by tubular prophylls at their base; spikelets in glomerules or solitary at tips of pedicels; scales of the spikelet spirally arranged, each subtending a single hypogynous flower; stamens 3 or fewer; anthers with apiculate apex, rounded at base; style 3- or 2-branched with minute rounded protrusions. Achenes usually less than 1.5 mm long, minutely papillate; epidermal cell structure of wavy inner cell walls with buttresses and apical nodules; bristles 6 or fewer at base of achene, retrorsely barbed or smooth.

Key to Species of *Scirpus*

A. Bristles retrorsely barbed, nearly straight (curled and crisped in No. 2) or wanting (B)

- B. Spikelets solitary on the branches of the inflorescence, rarely in clusters of 2 or 3, the lateral ones of each group long-pedicelled; mature scales with broad green midribs . . . . 1. *S. divaricatus*
- B. Spikelets clustered in glomerules on the branches of the inflorescence, rarely solitary; midrib of mature scales narrow, inconspicuous (C)
  - C. Leaves 10-20 per culm, crowded; spikelet scales rounded, about as long as wide; bristles curled and crisped, to over twice as long as achene when fully extended . . . . 2. *S. polyphyllus*
  - C. Leaves fewer than 10 per culm, internodes prolonged, spikelet scales ovate to elliptic-ovate; bristles at most 1-1/4 as long as achene or wanting. (D)
    - D. Bristles coarsely barbed almost to the base; rays of the inflorescence antrorsely scabrous their entire length (E)
      - E. Leaf sheaths reddish near base; blades 10-25 mm wide; achenes subtrigonous, 0.9-1 mm wide; bristles frequently caducous. . . . . .3. *S. expansus*
      - E. Leaf sheaths green throughout; blades 2-8(-10) mm wide; achenes plano-convex, 0.6-0.7 mm wide; bristles persistent. . . . . 4. *S. ancistrochaetus*
    - D. Bristles barbed only above the middle; rays of the inflorescence smooth or only slightly scabrous near the apex (F)
      - F. Bristles 0 (-3), shorter than the achene; barbs if present concentrated near the tips of the bristles . . . . 5. *S. georgianus*
      - F. Bristles usually 5 or 6, shorter than to slightly longer than the achenes; barbs extending downward from the tips of all or at least some of the bristles (G)
        - G. Mature culms reclining with inflorescences bending over to (or nearly to) the ground; lower leaf sheaths and blades inconspicuously septate-nodulose, nearly smooth; glomerules frequently with fewer than 15 spikelets; lower scales blackish, slightly mucronate. . . . . 6. *S. flaccidifolius*
        - G. Mature culms ascending or nearly so; lower leaf sheaths and blades conspicuously septate-nodulose or nearly smooth; glomerules frequently with more than 15 spikelets; scales blackish to brownish, mucronate (H).
          - H. Lower leaf blades and sheaths septate-nodulose; spikelets (2-) 3.5-5 (-8) mm long; scales brownish; longer bristles exceeding achenes . . . . 7. *S. atrovirens*
          - H. Lower leaf blades and sheaths inconspicuously septate-nodulose, nearly smooth; spikelets 2-3.5 mm long; scales blackish; longer bristles shorter than to equaling achenes . . . 8. *S. hattorianus*

A. Bristles smooth, curled and crisped, elongated (I)

- I. Mature bristles greatly elongated, strongly curled, exceeding the scales and giving the spikelets a woolly appearance; spikelets rarely solitary; scales with inconspicuous midribs; achenes less than 1 mm long . . . . . . 9. *S. cyperinus*

- I. Mature bristles shorter, curled, rarely exceeding the scales; spikelets predominantly solitary or in glomerules of 2 (-3); scales with conspicuous keeled, green midribs; achenes more than 1 mm long (J)
  - J. Leaves (5-) 8-15 mm wide; ultimate rays of the inflorescence and pedicels scabrous, with axillary bulblets; mature culms reclining with the inflorescences bending over to (or nearly to) the ground with 2 to 3 lateral inflorescences in addition to the terminal inflorescence . . . 10. *S. lineatus*
  - J. Leaves 3-8 (-10) mm wide; ultimate rays of the inflorescence and pedicels smooth, lacking axillary bulblets; mature culms ascending with terminal inflorescence only or rarely with 1 or 2 lateral inflorescences . . . . 11. *S. pendulus*

01. **Scirpus divaricatus** Ell., Sketch Bot. S. Carolina 1: 88. 1816. Fig. 2e.
Isolepis divaricata (Ell.) A. Dietr., Sp. Pl. 2: 131. 1832.

DESCRIPTION. **Rhizomes** short, obscure. **Culms** at maturity weak, reclining, obtusely angled, leafy, the nodes proliferating. **Leaves** 10-20 per culm; **sheaths** eligulate; **blades** 1-8 mm wide, crowded, smooth to weakly scabrous along margins and midvein beneath. **Involucral bracts** 3-5, reduced, the lowermost leaf-like; **rays** firm, upwardly scabrous along the ribs, elongate, at maturity becoming divaricate to sub-pendulous, frequently proliferating in the axils; **spikelets** lance-ovoid to linear cylindric, 3-15 mm long, 1.5-2 mm wide, central spikelet of each group sessile, the lateral ones long pedicelled, predominantly solitary at ray tips or rarely in clusters of 2-3; **scales** cucullate-ovate, 1-1.8 mm long, 1-1.3 mm wide, the sides light brown to reddish, scarious margined, with broad green midrib ca. 0.6-0.7 mm wide, rounded to short mucronate at the apex; **stamens** up to 3; **anthers** 0.8-0.9 mm long; **style** 3-branched. **Achene** trigonous with protruding angles and concave sides, ellipsoid to obovoid, somewhat stipitate at base, short-beaked, 0.7-1 mm long, 0.7-0.8 mm wide, surface smooth, yellowish brown to brown; **bristles** 6, minutely barbellate at the apex, reddish, shorter than to equaling the achene.

FLOWERING AND FRUITING. Late May-June; June-Aug.

DISTRIBUTION. Occurs in Chesapeake, Dinwiddie, Greensville, Nansemond, Prince George, Southampton, and Sussex counties in southeastern Virginia (see Harvill et al. 1992); Florida to Louisiana, north to southeastern Virginia, southern Tennessee, and southeastern Missouri.

HABITAT IN VIRGINIA. Lowland swamps and wooded bottomlands along rivers (often associated with *Taxodium*).

DISTINGUISHING FEATURES. This species is distinguished by its sharply trigonous achenes; scales with broad, green midrib (ca. 0.6-0.7 mm wide); and at maturity, its long, divaricately branched inflorescence with bulblets developing at the nodes.

02. **Scirpus polyphyllus** Vahl, Enum. Pl. 2: 274. 1806. Figs. 2f, 5. (See Schuyler in Proc. Acad. Nat. Sci. Philadelphia 119: 312, 1967, for a complete list of synonyms.)

DESCRIPTION. **Rhizomes** short, tough, fibrous, 4-6 mm thick. **Culms** obtusely angled. **Leaves** 10-20 per culm; **sheaths** short ligulate at adaxial junction of sheath and blade; **blades** 3-10 mm wide, to 3 dm long, scabrous on margins and midvein beneath. **Involucral bracts** 3-4, the lowermost leaf-like; **rays** firm, smooth, ascending to divaricate, frequently proliferating in the axils; **spikelets** ovoid, rufescent, 3-4 mm long, 2-2.5 mm wide, in

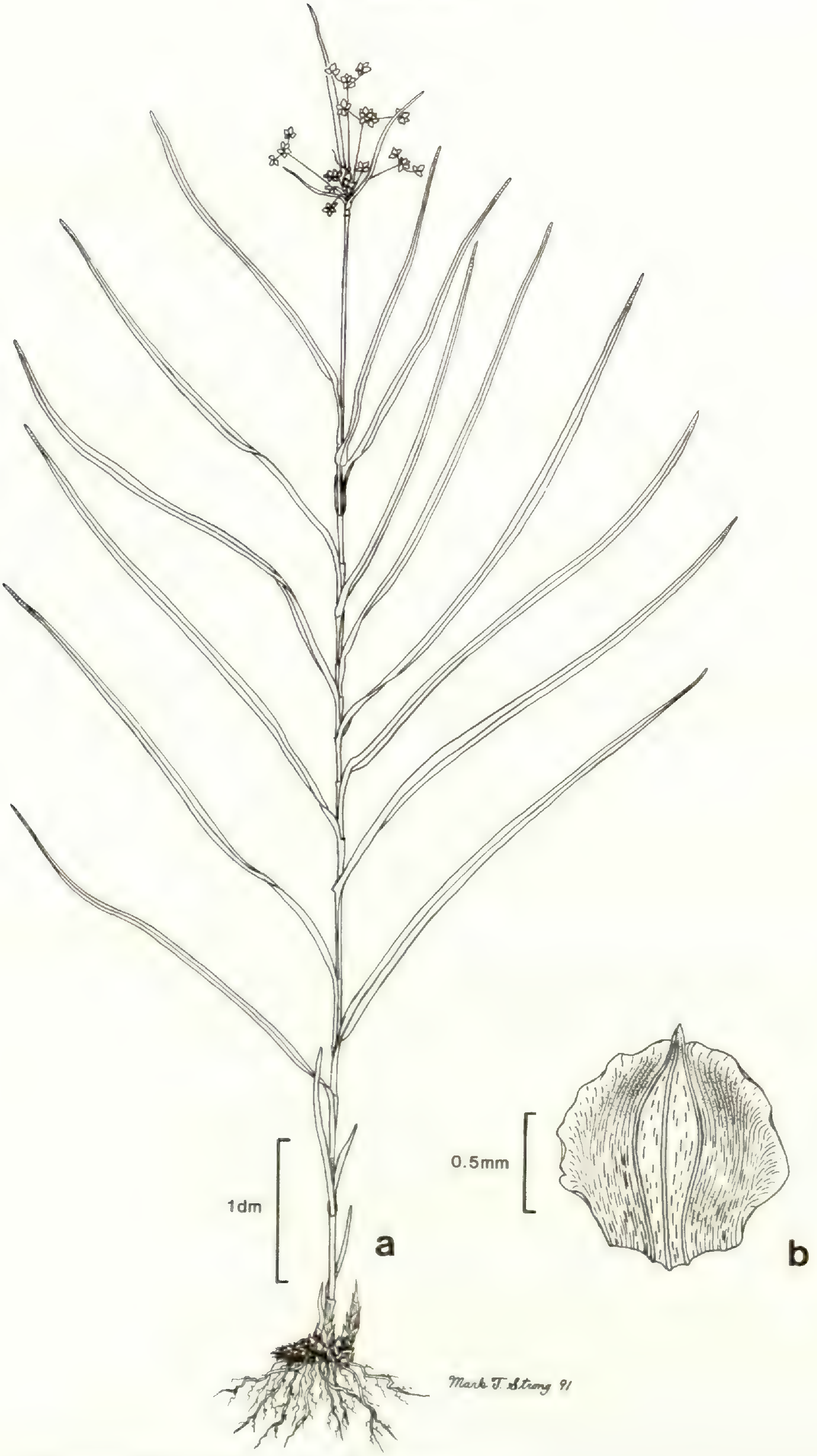

1dm
a
0.5mm
b
Mark T. Strong 91

FIG. 5. *Scirpus polyphyllus*. (a) habit. (b) spikelet scale.

glomerate clusters or 3-8 at ray tips; **scales** rounded, 1-1.5 mm long, about as wide, reddish brown to brownish black, the greenish midrib short mucronate at apex; **stamens** 3; **anthers** 0.9-1 mm long; **style** 3-branched. **Achene** plano-convex, obovate or nearly obtriangular, 1.1-1.3 mm long, 0.8-1 mm wide, smooth, pale brown; **bristles** 6, curled and crisped, retrorsely barbed above the middle, to over twice as long as the achene when fully extended.

FLOWERING AND FRUITING. June-early July; July-Sept.

DISTRIBUTION. Widely distributed in the piedmont and mountains, but absent from southeastern Virginia and the outer coastal plain (see Harvill et al. 1992); additional counties not recorded by Harvill et al. 1992: Caroline Co., *Strong, Kelloff & Bradley 677* (GMUF) and Roanoke Co., *Woods 743* (PH); New Hampshire to Missouri, south to Georgia, Tennessee, and Alabama.

HABITAT IN VIRGINA. Generally shaded areas along stream edges, roadside ditches, magnolia swamps, springy ground in woodland, wet meadows, swampy bottomland, sphagnous swales, wet clearings, and swampy streamsides.

DISTINGUISHING FEATURES. This species can be distinguished by its many-noded culms with 10-20 leaves; ovoid to rounded-ovoid spikelets; rounded, dark brown to brownish black mucronate scales; and obovate achenes bearing 6 curled and crisped bristles, retorsely barbed above the middle, to over twice as long as the achene when fully extended.

03. **Scirpus expansus** Fern., Rhodora 45: 293. 1943. Fig. 1e.

DESCRIPTION. **Rhizomes** reddish, elongate, 4-5 mm thick. **Culms** obtusely angled, stout, up to 1.5 cm wide near base. **Leaves** 6-9 per culm; **sheaths** reddish near their bases, septate-nodulose, short-ligulate at adaxial junction of sheath and blade; **blades** 1-2.5 cm wide, to 6 dm long, septate-nodulose, scabrous on margins and midvein beneath. **Involucral bracts** 3-8, leaf-like, the lowermost overtopping the inflorescence; **rays** firm, ascending to divaricate, antrorsely scabrous along the ribs. **spikelets** ovoid, 2-6 mm long, 1-2.5 mm wide, in glomerate clusters of 3-12 at ray tips; **scales** ovate, keeled, 1.3-2.0 mm long, 1-1.2 mm wide, brown to brownish black, the green midrib extending as a short mucro at apex; **stamens** 3; **anthers** ca. 1 mm long; **style** 3-branched. **Achene** subtrigonous to plano-convex, broadly ellipsoid, 1-1.2 mm long, 0.9-1 mm wide, yellowish brown; **bristles** 6, retrorsely barbed to base, frequently disarticulating from the achene and remaining within the scales, shorter than to equaling or exceeding the achene.

FLOWERING AND FRUITING. Mid June-early July; July-Aug.

DISTRIBUTION. Primarily in the mountains of midwestern and southwestern Virginia with several stations on the inner coastal plain (see Harvill et al. 1992); Maine to Michigan, south to Georgia.

HABITAT IN VIRGINIA. Creek edges, springheads, meadows, mountain streams, and seepage slopes.

DISTINGUISHING FEATURES. *S. expansus* is similar to *S. ancistrochaetus* in that the rays of the inflorescence are antrorsely scabrous their entire length and the hypogynous bristles are almost identical, but can be distinguished from *S. ancistrochaetus* by a number of other characters. The septate-nodulose sheaths of *S. expansus* are red-tinged near their bases and have wide, septate-nodulose blades that range in size from 10-25 mm wide, while those of *S. ancistrochaetus* are green near their bases with blades ranging from 2-8(-10) mm wide. Culms of *S. expansus* are much stouter at the base than those of *S. ancistrochaetus*, ranging up to 15 mm in width. The inflorescence of *S. expansus* is much more branched than that of *S. ancistrochaetus*. The achenes of *S. expansus* are subtrigonous, wider (0.9-1 mm), and subtended by brownish black scales, while those of *S. ancistrochaetus* are plano-convex, narrower (0.6-0.7 mm), and subtended by reddish brown scales.

04. **Scirpus ancistrochaetus** Schuyler, Rhodora 64: 44. 1962. Fig. 1f.

DESCRIPTION. **Rhizomes** short, woody. **Culms** obtusely angled, to 1 cm wide near base. **Leaves** 5-9 per culm, septate-nodulose at base, scabrous on margins and midvein beneath; **sheaths** short ligulate at adaxial junction of sheath and blade; **blades** 2-8 (-10) mm wide, up to 5 dm long. **Involucral bracts** 4-5, the lowermost leaf-like; **rays** firm, ascending, arching at maturity, antrorsely scabrous along the ribs; **spikelets** ovoid, 3-4 mm long, 2-3 mm wide, in glomerate clusters at ray tips; **scales** ovate-elliptic, 1.5-2 mm long, 1-1.2 mm wide, reddish brown, the green midrib extending as a short mucro at apex; **stamens** 0-3; **anthers** 1-1.1 mm long; **style**, 3-branched. **Achene** plano-convex, elliptic-obovate, 1-1.6 mm long, 0.6-0.7 mm wide, yellow-brown; **bristles** 6, retrorsely barbed nearly to the base, equaling to slightly longer than the achene.

FLOWERING AND FRUITING: Late May-June; June-July.

DISTRIBUTION. Rare in Alleghany, Bath, and Rockingham counties; New Hampshire, Vermont, Massachusetts, New York, Pennsylvania, West Virginia, and Maryland. This species is listed as LE (Endangered) by the United States Fish and Wildlife Service (1991), and LE by the Virginia Department of Conservation and Recreation (1993).

HABITAT IN VIRGINIA. Mountain sinkhole ponds.

DISTINGUISHING FEATURES. *Scirpus ancistrochaetus* is similar vegetativiely to other species in the genus *Scirpus* that have stiff, ascending to divergent primary inflorescence rays, the ultimate rays tipped by 1-many glomerules of spikelets (e.g. *S. atrovirens*, *S. expansus*, *S. flaccidifolius*, *S. georgianus*, *S. hattorianus* and *S. polyphyllus*). Frequently confused with *S. atrovirens*, it differs in a number of characteristics. The inflorescence rays of *S. ancistrochaetus* are antrorsely scabrous their entire length, while in *S. atrovirens* and other species with similar inflorescence type (with the exception of *S. expansus*), they are smooth or only slightly antrorsely scabrous near the tip. The achenes of *S. ancistrochaetus* are generally longer than those of *S. atrovirens* (1-1.6 mm long in the former, 1-1.3 mm long in the latter), and the bristles of *S. ancistrochaetus* are rigid with sharp-pointed, retrorse teeth that extend nearly to the base, while those of *S. atrovirens* are frequently wrinkled with round-tipped, retrorse teeth that are concentrated towards the tip of the bristle (Schuyler 1962).

05. **Scirpus georgianus** Harper, Bull. Torrey Bot. Club 27: 331. 1900. Fig. 1c.
Scirpus atrovirens var. *georgianus* (Harper) Fern., Rhodora 23: 134. 1921.

DESCRIPTION. **Rhizomes** short, stout, 5-8 mm thick. **Culms** obtusely angled. **Leaves** firm, 4-9, the lower leaves and sheaths with few septate partitions between the veins; **sheaths** short ligulate at adaxial junction of sheath and blade; **blades** 0.2-1.5 cm wide, to 5 dm long, scabrous on margins and midvein beneath; **Involucral bracts** 2-4, the lowermost leaf-like; **rays** firm, smooth, ascending to divaricate; **spikelets** ovoid, 2-4 mm long, 1-2 mm wide, in glomerate clusters at ray tips, these usually with 15 or more spikelets; **scales** rounded-ovate, 1.2-1.8 mm long, 0.8-1 mm wide, brownish to brownish black, the green midrib short mucronate at apex; **stamens** 2 or 3; **anthers** ca. 1 mm long; **style** 3-branched. **Achene** plano-convex, elliptic, 0.7-1.1 mm long, 0.5-0.6 mm wide, smooth, pale brown; **bristles**

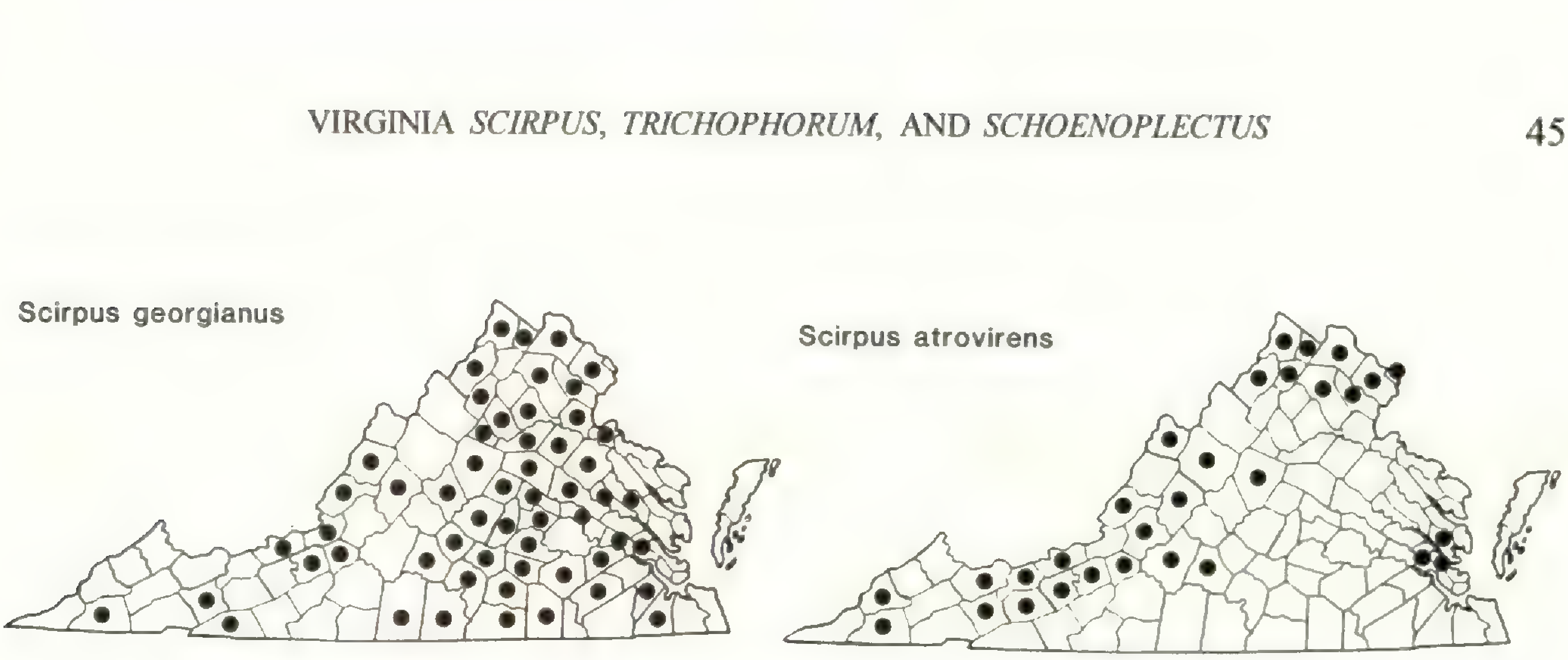


FIG. 6. Distribution of *Scirpus atrovirens* and *Scirpus georgianus* in Virginia.

usually absent or rarely represented by 1-3 short ones, less than 3/4 the length of the achene.

FLOWERING AND FRUITING. Late May-June; June-Aug., sometimes into Sept. and Oct.

DISTRIBUTION. Widely distributed on the piedmont and coastal plain of Virginia (Fig. 6); Local on Prince Edward Island and in Wisconsin, west to Nebraska and eastern Texas, south to Georgia (more common in southeastern United States).

HABITAT IN VIRGINIA. Damp soils in swales, marshes, wet meadows, roadside ditches, borders of beaver ponds, and along streams and creeks.

DISTINGUISHING FEATURES. See *S. atrovirens.*

06. **Scirpus flaccidifolius** (Fern.) Schuyler, Rhodora 69: 198. 1967. Fig. 1d.
Scirpus atrovirens var. *flaccidifolius* Fern., Rhodora 40: 396. 1938.

DESCRIPTION. **Rhizomes** stout, 4-7 mm thick. **Culms** obtusely angled, weak, at maturity arching or reclining; the inflorescences frequently bending over to the ground. **Leaves** 8-12, the lower leaves and sheaths with few septate partitions between the veins; **sheaths** short ligulate at adaxial junction of sheath and blade; **blades** 0.6-1.2 cm wide, up to 6 dm long, scabrous along margins and midvein beneath. **Involucral bracts** 2-4, the lowermost leaf-like; **rays** firm, smooth, ascending to divaricate; **spikelets** ovoid, 3-3.2 mm long, 2-3 mm wide, in glomerate clusters of fewer than 15 at ray tips; **scales** elliptic to elliptic-obovate, 1.3-1.9 mm long, 1-1.1 mm wide, brown to brownish black, the green midrib prolonged as a short mucro at apex; **stamens** 2 or 3; **anthers** ca. 1 mm long; **style** 3-branched. **Achene** plano-convex, elliptic, 1-1.2 mm long, 0.6-0.7 mm wide, pale brown; **bristles** 6, retrorsely barbed above the middle, shorter than to equaling the achene.

FLOWERING AND FRUITING. Late May-early June; June-July.

DISTRIBUTION. Known only from southeastern Virginia in Greensville, Southampton, and Sussex counties and northeastern North Carolina. This species is listed as S1 (extremely rare in the state) by the Virginia Department of Conservation and Recreation (1993).

HABITAT IN VIRGINIA. Wooded bottomlands.

DISTINGUISHING FEATURES. See *S. atrovirens.*

07. **Scirpus atrovirens** Willd., Enum. Pl. 1: 79. 1809. Fig. 1a. (See Schuyler in Proc. Acad. Nat. Sci. Philadelphia 119: 310, 1967, for a complete list of synonyms.)

DESCRIPTION. **Rhizomes** stout, 5-8 mm thick. **Culms** obtusely angled. **Leaves** firm, 4-9; **sheaths** short ligulate at adaxial junction of sheath and blade, the lowermost septate-nodulose; **blades** 0.2-1.8 cm wide, to 5 dm long, scabrous along margins and midvein beneath, the lower septate-nodulose. **Involucral bracts** 2-5, the lowermost leaf-like; **rays** firm, smooth, ascending to divaricate; **spikelets** ovoid, (2-) 3.5-5 (-8) mm long, 1-2 mm wide, in glomerate clusters at ray tips, these usually with 15 or more spikelets; **scales** rounded-ovate, 1.4-2.1 mm long, 0.9-1.1 mm wide, brownish, the green midrib short mucronate at apex; **stamens** 2 or 3; **anthers** ca. 1 mm long; **style** 3-branched. **Achene** plano-convex, elliptic, 1-1.3 mm long, 0.5-0.6 mm wide, pale brown; **bristles** 6, barbed on upper 2/3, shorter than to slightly exceeding the achene.

FLOWERING AND FRUITING. Late May-June; June-Aug.

DISTRIBUTION. Primarily in the foothills and mountains of northern and western Virginia with several stations on the inner coastal plain (Fig. 6); Newfoundland south to Georgia and eastern Texas, disjunct occurrences in Minnesota (more common in northeastern United States).

HABITAT IN VIRGINIA. Damp soils in swales, marshes, wet meadows, marshy seepages, roadside ditches, and stream edges.

DISTINGUISHING FEATURES. *Scirpus atrovirens* is closely related to *S. flaccidifolius*, *S. georgianus*, and *S. hattorianus*. They are all similar in habit, but differ consistently from each other in a number of characteristics (also see discussion below). *Scirpus atrovirens* can be distinguished from other species in this group by its coarse, elongate, retrorsely barbed bristles which frequently exceed the achene; septate-nodulose sheaths and leaf blades; and longer spikelets (2-) 3.5-5 (-8) mm long (vs. 2-4 mm long in other species). *Scirpus flaccidifolius* has elongate, lax, and reclining culms that bend over to the ground, in contrast to the shorter, firm and upright culms of other species in this group; longer primary inflorescence rays which rarely contain more than 15 spikelets per glomerule; relatively smooth to inconspicuously septate-nodulose lower leaf sheaths and blades; and short, slightly mucronate tips of lower scales (Schuyler 1967c). *Scirpus georgianus* can be readily distinguished from other members of this group by its lack of bristles or one, two, or rarely three short to rudimentary ones. *Scirpus hattorianus* has delicate, retrorsely barbed, hypogynous bristles which are shorter than to barely reaching the summit of the achene; shorter spikelets than *Scirpus atrovirens* (2-3.5 mm long in *S. hattorianus* vs. (2-) 3.5-5 (-8) mm long in *S. atrovirens*); and dark brown to black scales (Schuyler, 1967b).

DISCUSSION. The "*Scirpus atrovirens* group," as here specified, consists of four species (*S. atrovirens*, *S. georgianus*, *S. hattorianus*, and *S. flaccidifolius*). These were all treated by Fernald (1950) as *S. atrovirens*. Schuyler (1967a), showed that these four species can be distinguished morphologically, and that the characters distinguishing them from each other were consistent over their entire range. He also found that the four species could be separated geographically as well as phenologically.

Scirpus atrovirens has a more northern range in the eastern United States, occurring northward to southern Canada. In Virginia, it is primarily confined to upland habitats (Fig. 6). *S. georgianus* has a more southern range in the eastern United States, occurring only in disjunct populations northward. In Virginia, it is primarily confined to lowland areas on the piedmont and coastal plain (Fig. 6). *Scirpus hattorianus* is sympatric with *S. atrovirens* northward, but it is more common in New England, Quebec, and the Maritime Provinces. It occurs only in disjunct populations southward (Maryland, Virginia, North Carolina, Tennessee, Alabama, and Indiana). In northern populations of *S. atrovirens* and *S. hattorianus* where their ranges overlap, *S. hattorianus* is primarily found in upland meadows and ditches, while *S. atrovirens* is primarily found in lowland marshes. *Scirpus flaccidifolius* is a rare species known only from wooded bottomlands in southeastern Virginia and northeastern North Carolina.

08. **Scirpus hattorianus** Makino, J. Jap. Bot. 8: 44. 1933. Fig. 1b.

DESCRIPTION. **Rhizomes** stout. **Culms** obtusely angled. **Leaves** firm, 10-18, the lower leaves and sheaths with few septate partitions between the veins; **sheaths** short ligulate at adaxial junction of sheath and blade; **blades** 2-10 mm wide, to 5 dm long. **Involucral bracts** 2-4, the lowermost leaf-like; **rays** smooth, ascending to divaricate; **spikelets** oblong-ovoid, 2-3.5 mm long, 1.5-2.5 mm wide, in glomerate clusters at ray tips, these usually with 15 or more spikelets; **scales** rounded-ovate, 1.2-2 mm long, 0.9-1.1 mm wide, brownish black to blackish, the green midrib short-mucronate at apex; **stamens** 2-3; **anthers** 0.9-1 mm long; **style** 3-branched. **Achene** plano-convex, elliptic-obovate, 0.8-1.1 mm long, 0.6-0.8 mm wide, pale brown; **bristles** 5 or 6, retrorsely barbed above the middle, shorter than to equaling the achene.

FLOWERING AND FRUITING. Early June-July; late July-Aug.

DISTRIBUTION. Known only from a single collection: Highland County, low, wet field just south of Monterrey, *B. Mikula 6797*, 23 July 1950 (FARM, WILLI); Newfoundland to western Ontario, south to Maryland, Virginia, West Virginia, Tennessee, North Carolina, Alabama, Ohio, Indiana, and Wisconsin (more common in northeastern United States).

DISTINGUISHING FEATURES. See *S. atrovirens*

09. **Scirpus cyperinus** (L.) Kunth, Enum. Pl. 2: 170. 1837. Fig. 2c.
Eriophorum cyperinum L., Sp. Pl., ed. 2, 1:77. 1762.
Scirpus rubricosus Fern., Rhodora 47: 124. 1945. (See Schuyler in Proc. Acad. Nat. Sci. Philadelphia 119: 319, 1967, for a complete list of synonyms.)

DESCRIPTION. **Rhizomes** short, stout, up to 2 cm thick at culm bases, branching; **roots** minutely scabrous-papillate, or hirsute with pale brown hairs. **Culms** nearly terete. **Leaves** many, rigid, crowded at base, curving; **sheaths** reddish, with short ligule at adaxial junction of sheath and blade; **blades** narrowly linear, 3-10 mm wide, to 6 dm long, harshly scabrous along margins and midveins beneath. **Inflorescence** pendulous, drooping at maturity; **involucral bracts** 3-5, elongate, leaf-like, with reddish brown to brownish black bases; **rays** flexuous, antrorsely scabrous, involucels at base reddish brown; **spikelets** ovoid to broadly ovoid, 4-6 mm long, 2-3 mm wide, in glomerules of 2-7, or sometimes in dense glomerules, rarely solitary; **scales** ovate to elliptic, 1.1-2.1 mm long, ca. 1 mm wide, reddish brown to brownish black, the green midrib obtuse to mucronate at apex; **stamens** 1 or 2; **anthers** 0.9-1 mm long; **style** 3-branched. **Achene** subtrigonous to plano-convex, ellipsoid, 0.6-0.9 mm long, 0.4-0.5 mm wide, pale-brown; **bristles** 6, elongate, contorted, exceeding the scales at maturity, barbs lacking.

FLOWERING AND FRUITING. July (later in mountains); Aug.-Oct.

DISTRIBUTION. Common throughout the state (see Harvill et al. 1992); Newfoundland to Nova Scotia, south to Florida and Texas, westwards to West Virginia, Ohio, Indiana, Illinois, Minnesota, Iowa, Oklahoma, and Mexico.

HABITAT IN VIRGINIA. Open areas of peaty depressions, marshes, meadows, pond borders, creeks, roadside ditches, and disturbed areas.

DISTINGUISHING FEATURES. This species is readily distinguished by its nearly terete culms; elongate, narrow, rigid, curving, scabrous-margined leaves and involucral bracts; and large, pendulus, paniculate-corymbose inflorescence.

10. **Scirpus lineatus** Michaux, Fl. Bor.-Amer. 1: 32. 1803. Fig. 2d.
Scirpus fontinalis Harper, Bull. Torrey Bot. Club 30: 322, 1903. (See Schuyler in Proc. Acad. Nat. Sci. Philadelphia 119: 306, 1967, for a complete list of synonyms.)

DESCRIPTION. **Rhizomes** horizontal, stout, 5-8 mm thick. **Culms** obtusely angled, at maturity weak, reclining. **Leaves** 4-8; **sheaths** eligulate; **blades** (5-) 8-15 mm wide, scabrous along margins and midvein beneath. **Inflorescence** terminal and axillary from 2 or 3 of the upper leaves, pendulous, divaricately branching; **involucral bracts** 3-5 on terminal inflorescence, reduced, the lowermost leaf-like, 1-2 short and subulate or wanting on lateral inflorescences; **rays** flexuous, upwardly scabrous along ribs, frequently developing axillary bulblets; **spikelets** ovoid to lance-ovoid, 4-7 (-10) mm long, 2-3 mm wide, predominantly solitary at ray tips or rarely in clusters of 2-3; **scales** ovate to narrowly elliptic, 1.8-2.5 mm long, 2-2.2 mm wide, lustrous with brown to reddish brown sides, the green midrib cuspidate to mucronate at apex; **stamens** 3; **anthers** 1-1.2 mm long; **style** 3-branched. **Achene** trigonous to plano-convex, ellipsoid, beaked, with stipitate base, 1.2-1.4 mm long, 0.6-0.7 mm wide, minutely papillate, surface pale brown; **bristles** 6, yellowish translucent, curled and wrinkled, shorter than to slightly exceeding the achene, barbs lacking.

FLOWERING AND FRUITING. Apr.-May; late May-July.

DISTRIBUTION. Occurs only on the inner coastal plain in Gloucester, James City, Surry, and York counties and the City of Hampton (see Harvill et al. 1992); Florida to Louisiana north on coastal plain to southeastern Virginia.

HABITAT IN VIRGINIA. Moist shaded places in wooded calcareous spring-heads, meadows, swampy woods, bluffs, gullies, and swales.

DISTINGUISHING FEATURES. *Scirpus lineatus* is closely related to *Scirpus pendulus* but can be distinguished from the latter by its 2-3 lateral inflorescences in addition to the terminal inflorescence; scabrous rays with axillary bulblets; wider leaves; and weak, reclining culms, whereas *Scirpus pendulus* has a terminal inflorescence only, or one or rarely two lateral inflorescences; smooth rays lacking axillary bulblets; and rigid, upright culms.

NOMENCLATURE. This species has been known as *Scirpus fontinalis* Harper in many North American floras including Small (1933), Beetle (1947), Fernald (1950), Gleason (1952), and Radford et al. (1968). Schuyler (1966), upon examining the type specimens of *S. fontinalis* and *Scirpus lineatus* Michx., discovered that they were conspecific, and that plants being treated as *S. lineatus* Michx. (by authors of the above-mentioned floras), were actually the species described by Muhlenberg in 1813 as *S. pendulus*. Since *S. lineatus* was described earlier than *S. fontinalis*, plants previously recognized as *S. fontinalis* should be correctly treated as *S. lineatus*, and those plants previously recognized as *S. lineatus* should be correctly treated as *S. pendulus*.

11. **Scirpus pendulus** Muhl., Cat. Pl. Amer. Sept. 7. 1813. Fig. 2a. (See Schuyler in Proc. Acad. Nat. Sci. Philadelphia 119: 307, 1967, for a complete list of synonyms.)

DESCRIPTION. **Rhizomes** stout, 0.5-1 cm thick. **Culms** obtusely angled, rigid, upright. **Leaves** crowded at base, less than 10 per culm; **sheaths** eligulate; **blades** 3-8 (-10) mm wide, to 3 dm long, scabrous along margins and midvein beneath. **Inflorescence** terminal or rarely with one or two lateral inflorescences from the upper leaf axils, pendulous; **involucral bracts** 3-5 on terminal inflorescence, reduced, the lowermost leaf-like, 1-2 short and subulate or wanting on lateral inflorescences; **rays** flexuous, smooth, lacking axillary bulblets; **spikelets** ovoid to sub-cylindric, 6-12 mm long, 2-3 mm wide, predominantly solitary at ray tips; **scales** ovate, 2 mm long, 0.8-1.1 mm wide, lustrous, reddish brown or brownish, the greenish midrib ending in a short, recurved cusp at apex; **stamens** 3; **anthers** ca. 1 mm long; **style** 3-branched. **Achene** at maturity trigonous to plano-convex, ellipsoid, beaked with stipitate base, 1-1.2 mm long, 0.6-0.7 mm wide, lustrous pale brown to grayish brown, minutely papillate; **bristles** 6, yellow- to reddish translucent, curling, exceeding the achene.

FLOWERING AND FRUITING. May-June; late May-July.

DISTRIBUTION. Primarily occurs in the foothills and mountains of northern and western Virginia with several stations in the piedmont and inner coastal plain (see Harvill et al. 1992); additional counties not recorded by Harvill et al. 1992: Albemarle Co., *Stevens 5447* (FARM) and Smyth Co., *Small s.n.* (NY,PH); Maine, west to southern Canada, Iowa, and eastern Colorado, south to Florida and southwest to New Mexico and northern Mexico. In the western United States, *Scirpus pendulus* occurs in disjunct populations in Oregon and California.

HABITAT IN VIRGINIA. Moist open places in swales, along streambanks, open meadows, and roadside ditches.

DISTINGUISHING FEATURES. See *S. lineatus.*

NOMENCLATURE. See *S. lineatus.*

2. **Trichophorum** Persoon, Syn. Pl. 1: 69. 1805. nom. cons.
Type species: *T. alpinum* (L.) Persoon

Caespitose perennials with fibrous roots, frequently forming tussocks. Culms trigonous or terete. Leaves basal, bladeless, or the uppermost sheaths blade-bearing and ligulate, with closed, tubular sheaths. Inflorescence a single, terminal, erect spikelet (In North American species); involucral bract scale-like, simulating a fertile scale of the spikelet, the apex thickened, blunt; spikelets ovate to ovate-elliptic; scales spirally imbricate, 3-5 nerved, each subtending a single flower; stamens 3; anthers with apiculate apex; stigmas 3, with minute rounded protrusions. Achene trigonous, smooth to papillate; epidermal cell structure of non-wavy inner cell walls lacking buttresses and apical nodules; bristles 0-6, filiform, scaberulous, silky or with setulose hairs.

1. **Trichophorum planifolium** (Sprengel) Palla, Oesterr. Bot. Z. 63: 402. 1913. Figs. 2b, 7.

Isolepis planifolia Sprengel, Neue Ent. 3: 10. 1822.

Scirpus verecundus Fernald, Rhodora 50: 284. 1948, nom. nov. for *Scirpus planifolius* Muhlenberg, Descr. Gram. 32. 1817, non *Scirpus planifolius* Grimm, in Nova Acta Phys.-Med. Acad. Caes. Leop.-Carol. Nat. Cur. 3: App. 259. 1767.

Eleogiton planifolia (Sprengel) A. Dietrich, Sp. Pl. 2: 98. 1833.

Eleocharis planifolia (Sprengel) Nees, Linnaea 9: 294. 1834.

Baeothryon verecundum (Fernald) A. & D. Löve, Univ. Colorado Stud. Biol. Ser. No. 17: 15. 1965.

Baeothryon planifolium (Sprengel) Soják, Čas. Nár. Mus. Odd. Přír. 148: 193. 1979.

DESCRIPTION. Densely caespitose perennial with fibrous roots. **Culms** trigonous, upwardly scabrous on the angles, 1-4 dm tall. **Leaves** borne from base up to 1/4 the length

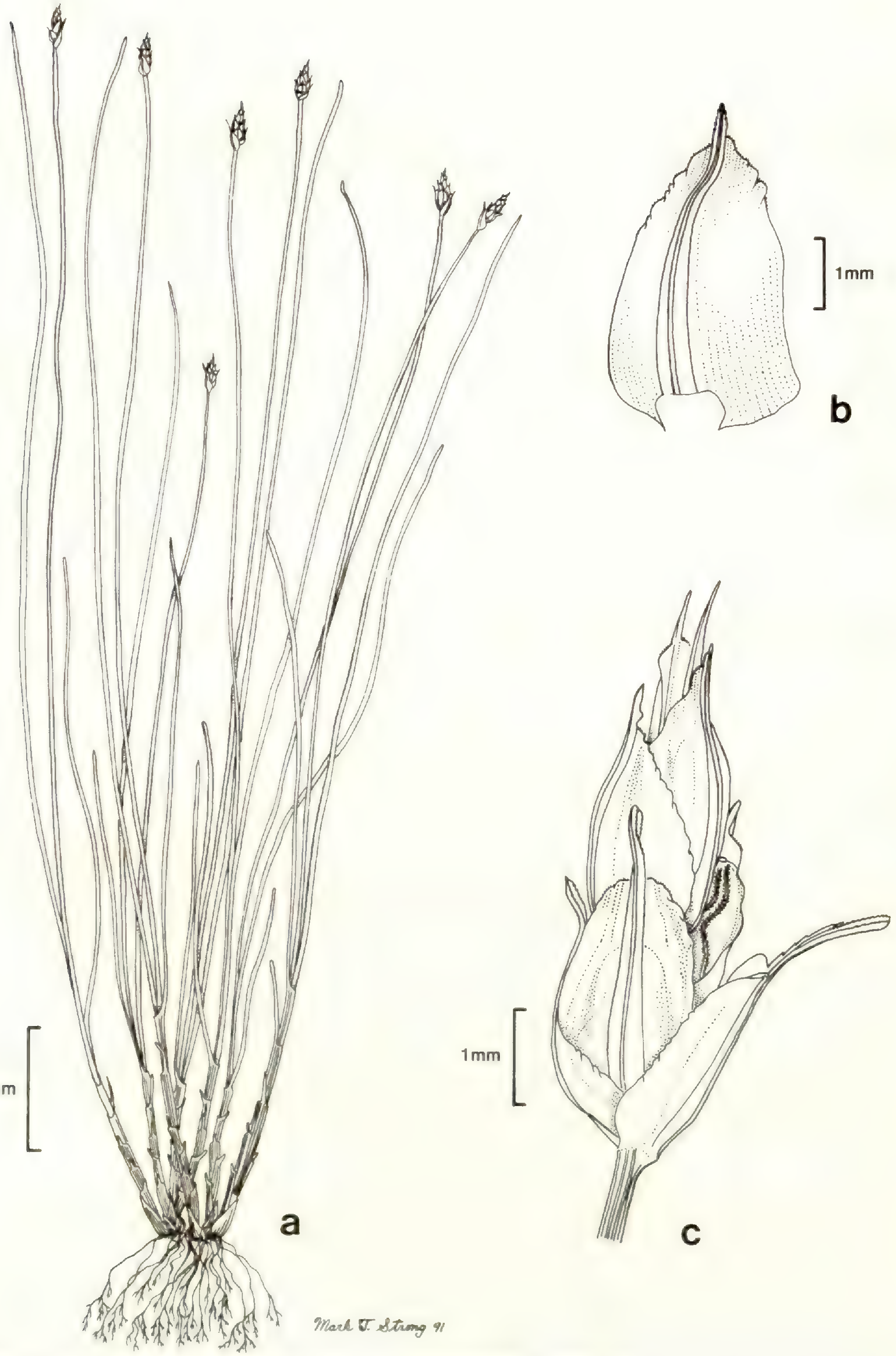

1mm
b
2cm
a
1mm
c
Mark T. Strong 91

FIG. 7. *Trichóphorum planifolium.* (a) habit. (b) spikelet scale. (c) spikelet.

of the culms, the upper elongate, shorter than to equaling or exceeding the culms; **sheaths** glabrous, with short firm to scarious ligule borne at adaxial junction of sheath and blade, the lower open, whitish to pale brown, red-dotted, sub-truncate at summit, with reddish brown to pale brown scarious margins, the upper closed, with U-shaped orifice, green, the inner band white, scarious; **blades** flat, 1-1.5 mm wide, with rounded cartilaginous tip, scabrous on margins, the lower short, subulate-thickened, the upper with elongate blades. **Inflorescence** a single, erect, terminal spikelet; **involucral bract** 1, scale-like, 1-6 mm long; **spikelet** ovate, 5-7 mm long, 2 mm wide; mature **scales** ovate, 3.5-4.5 mm long, 1.5-2 mm wide, sagittate at base, green to pale brown, the midrib prolonged into an awn up to 0.8 mm long on scales near base of spikelet, shorter on upper scales; **anthers** 1-1.2 mm long; **style** subulate, 3-branched, the branches with minute, rounded protrusions. **Achene** trigonous, ellipsoid, 2 mm long, 1-1.2 mm wide, pale brown to light grayish brown, minutely papillate; **bristles** 6, terete to flattened, up to 0.1 mm wide with ascending, setulose hairs, shorter than to equaling the achene.

FLOWERING AND FRUITING. April; late April-May.

DISTRIBUTION. Mountains and piedmont of Virginia, absent from the coastal plain (see Harvill et al. 1992); Maine to Ohio, south to southern New England, Delaware, Maryland, District of Columbia, and primarily uplands of Virginia, West Virginia, Kentucky, and Missouri.

HABITAT IN VIRGINIA. Dry upland forests, deciduous woods.

DISTINGUISHING FEATURES. *T. planifolium* can be readily distinguished by its solitary spikelet at the tip of the culm; small scale-like involucral bract; narrow leaf blades (1-1.5 mm wide); trigonous, papillate achenes; and hypogynous bristles with setulose hairs that are shorter than to equaling the achene.

DISCUSSION. Both the names *Trichophorum* Pers. and *Baeothryon* Dietr. have been applied to this species. Salmenkallio and Kukkonen (1989), studying the typification of both of these names, found that *Baeothryon* at present is only a synonym of the genus *Eleocharis* and that of the two uses of the name *Trichophorum* (as a section of *Scirpus* sensu stricto and traditionally, for the group of species related to *T. alpinum*) the traditional and correct use of the genus should be maintained.

3. **Schoenoplectus** (Rchb.) Palla, nom. cons., Verh. K.K. Zool. Bot. Ges. Wien 38, Sitzb.: 49. 1888.

Type species: *Schoenoplectus lacustris* (L.) Palla (*Scirpus lacustris* L.)

Emergent aquatics; perennials or annuals, with elongate, horizontal rhizomes or tufted. Culms trigonous or terete, glabrous, air cavities often present, leafy or leaves reduced to short protrusions from the bladeless sheaths. Inflorescences congested and head-like or anthelate with elongate rays, pseudolateral or pseudolateral at anthesis and appearing terminal at maturity; involucral bracts 1-2 (-3), the lowest appearing as a continuation of the culm, or (1-) 2-6, flattened and leaf-like; rays with tubular prophylls at base; spikelets ovoid, ellipsoid or cylindrical; stamens 2-3; anthers with prickly or barbed appendage at apex, sagittate at base; style sub-flattened to strap like; stigmas 2 or 3. Achenes plano-convex, trigonous or lenticular, brown or blackish at maturity; epidermal cell structure diverse; bristles 0-6, when present strap- or needle-like, retrorsely barbed with straight or recurved barbs.

Key to Species of *Schoenoplectus*

A. Involucral bracts 1 (-3), the lowest elongate, terete or triangular, appearing as a continuation of the culm; culms naked or leafy only towards base; scales glabrous or with prickle-like hairs; rhizomes usually etuberous (B)
  B. Inflorescence simple, spikelets sessile, in glomerules or solitary (C)
    C. Plants lacking rhizomes; culms slender, densely tufted; achenes 1.5-2 mm long, blackish at maturity; anthers 1 mm long or less (D)
      D. Mature achene cuneate-obovate, plano-convex, smooth to obscurely rugulose; bristles wanting or rudimentary, or when present, slender. .... 1. *Sch. smithii*
      D. Mature achene rounded-obovate, unequally biconvex, prominently pitted; bristles when present stout .... 2. *Sch. purshianus*
    C. Plants with elongate, horizontal rhizomes; culms mostly solitary or scattered; achenes 2-5 mm long, whitish, drab, olivaceous or brown at maturity; anthers 2-4 mm long (E)
      E. Achenes distinctly trigonous, with a beak 0.5-0.7 mm long at apex; culms 0.5-5 mm wide; scales entire (F)
        F. Spikelet solitary; culms terete, filiform; leaves numerous, blades crescentform-capillary .... 3. *Sch. subterminalis*
        F. Spikelets 1-4; culms trigonous, stout with concave sides; leaves 2 or 3, blades terete or triangular-channeled .... 4. *Sch. torreyi*
      E. Achenes plano-convex, with a beak 0.4 mm long or less at apex; culms 1-10 mm wide; scales with erose or ciliate margins (G).
        G. Mature culms wing-angled, 4-10 mm wide at upper sheath; involucral bracts 1-2 (-3.5) cm long; awns shorter than to equaling the shallowly cleft apex of scales; achenes 2-2.7 mm long; bristles flattened, with downcurved barbs. Plants restricted to coastal plain, primarily of brackish to saline habitats .... 6. *Sch. americanus*
        G. Mature culms not wing-angled, relatively slender, 1-6 mm wide at upper sheath; involucral bracts 2-15 cm long; awns exceeding the deeply emarginate apex of scales; achenes 2.5-3.0 (-3.2) mm long; bristles narrow, retrorsely barbed. Plants widespread in fresh to saline habitats. .... 7. *Sch. pungens*
  B. Inflorescence compound, usually with elongate branches (H).
    H. Culms terete; achenes 1.7-2.8 mm long, 1.3-2.0 mm wide, the subulate beak 0.1-0.3 mm long (I).
      I. Mature scales 2.5-3.2 mm long, the apex with a short, straight awn; spikelets 5-7 (-9) mm long, solitary or in clusters of 2-3 (-5) at ray tips; culms soft, easily compressed .... 8. *Sch. validus*
      I. Mature scales 3.5-4 mm long, the apex with a prominent, usually contorted awn; spikelets 6-15 mm long, occasionally solitary, but mostly clustered in glomerules of 3-7 at ray tips; culms firm .... 9. *Sch. acutus*
    H. Culms trigonous; achenes 3-4 mm long, 1.9-2.2 mm wide, the stout beak 0.8-1 mm long .... 5. *Sch. etuberculatus*

A. Involucral bracts (1-) 2-6, leafy, of two or more flat leaves; culms leafy; scales pubescent; rhizomes tuberous (J)
  J. Mature achenes trigonous, the acute angles forming an equilateral triangle in cross section; bristles persistent, exceeding the achene; spikelets cuneate at base; scales pale brown; plants of fresh habitats . . . . 10. *Sch. fluviatilis*
  J. Mature achenes plano-convex, dorsiventrally compressed; bristles few or wanting or if present, shorter than to equaling the achene; spikelets rounded to truncate at base; scales chestnut brown to rufescent; plants of brackish to saline habitats (K)
    K. Mature achenes reddish brown or dark brown, lustrous, the summit truncate, abruptly differentiated into the beak; bristles mostly caducous; plants primarily of saline shores and tidal marshes . . . . 11. *Sch. robustus*
    K. Mature achenes whitish to olive brown, dull, the summit rounded, gradually tapering into the beak; bristles persistent; plants primarily growing in marshes within the brackish zone between fresh and saline waters of tidal river systems . . . . 12. *Sch. novae-angliae*

01. **Schoenoplectus smithii** (A. Gray) Soják, Čas. Nár. Muz. Odd. Přír. 141(1-2): 62. 1972. Fig. 3e.
Scirpus smithii A. Gray, Manual Bot. Ed. 5. 563. 1867.

DESCRIPTION. Caespitose. **Culms** subterete to somewhat angled, septate, 1-4 dm long, 0.9-1.5 mm wide. **Leaves** bladeless, the upper sheaths with a few, short, callous-tipped blades, 2-10 cm long, or 1-2 elongate blades on upper sheaths; **sheaths** confined to basal portion of culm, acute, whitish to pale brown, with reddish-brown to pale brown scarious margins. **Inflorescence** pseudolateral, spikelets in a single, sessile glomerule; **involucral bract** 1, appearing as a continuation of culm, septate, 3/4 to 1/3 as long as the culm, callous-tipped; **spikelets** 1-9, ovoid, subacute, 0.4-1 cm long, 3-5 mm wide; **scales** oblong-ovate, 2.5-3.5 mm long, 2 mm wide, green to pale brown with scarious margins, the midrib prolonged into a short mucro; **stamens** 3; **anthers** narrowly oblong, 0.5 mm long, with a small, brown, triangular, prickly tip; **style** 2-branched, the branches smooth or with minute scales. **Achene** plano-convex, cuneate-obovate, 1.5-2 mm long, 1.2-1.5 mm wide, smooth to obscurely rugulose, lustrous, black; **bristles** absent (forma *smithii*), represented by minute rudiments at base, sometimes with 1-3 bristles and 1-3 minute rudiments, the bristles retrorsely barbed only at the very tip (forma *levisetus*), or 4-5 and well-developed with retrorse barbs (forma *setosus*).

FLOWERING AND FRUITING. July; late July-Aug.

DISTRIBUTION. Historically known from only a single locality: Fairfax County, along gravelly beach between tides, Hunting Creek, 3/4 mi. SSW of Alexandria, *G.H. Shull 214*, 12 Aug. 1902 (NY,US). New Brunswick and Quebec to Minnesota, south to southern New England, New Jersey, Delaware, northeastern Virginia, northwestern and southeastern Pennsylvania, northern Ohio, northern Indiana, and Illinois.

DISTINGUISHING FEATURES. *Schoenoplectus smithii* is closely related to *Sch. purshianus* but can be distinguished from the latter by its smooth to faintly rugulose, cuneate-obovate achenes and slender bristles which are either well-developed, short to rudimentary, or wanting, whereas *Sch. purshianus* has pitted, rounded-obovate, unequally biconvex achenes and 6 stout, retrorsely barbed bristles that exceed the achene.

DISCUSSION. Taxonomically, *Sch. smithii* has been confused with *Sch. purshianus*, and some authors, e.g., Beetle (1942) and Gleason and Cronquist (1963), have treated it as an "aquatic extreme" of *Sch. purshianus*. The pattern of infraspecific variation is very similar in both species and may have been the main cause of this confusion. The ecologically differentiated forms of each species were delineated by Fernald (1950). He described *Sch. smithii* as having three forms: f. *smithii* (bristles absent of rudimentary), f. *setosus* (bristles well developed with retrorse barbs), and f. *levisetus* (bristles nearly smooth). *Sch. purshianus* he described as having two forms: f. *purshianus* (bristles well developed with retrorse barbs) and f. *williamsii* (bristles absent or rudimentary). The forms of *Sch. smithii* are primarily associated with alkaline substrates and frequently occur in tidal estuarine habitats, while those of *Sch. purshianus* are primarily associated with more acid substrates and are never found in tidal estuarine habitats (Schuyler 1972a). The achenes of the specimen collected along a tidal shoreline of the Potomac River have nearly smooth bristles which are barbed only at the apex (Fig. 3e) and can be referred to f. *levisetus*. Whether a form of either species has retrorsely barbed bristles, bristles that lack barbules, or bristles are absent or rudimentary, seems to depend on the habitat they are restricted to. The typical forms of both species which have retrorsely barbed bristles occur in habitats that have little or moderate water fluctuation, while those forms with bristles lacking barbs or the bristles are absent or rudimentary, occur primarily in habitats where there is substantial water level fluctuation (e.g. tidal shorelines). The absence of bristles, or the absence of barbs on bristles appears to be an adaptation to the periodic water level fluctuations that occur in estuarine environments (Schuyler, 1972a). Tidal emergent forms usually have septate-nodulose culms, sheaths, and leaves, while those of non-tidal habitats have septate-nodulose sheaths only.

02. **Schoenoplectus purshianus** (Fernald) M. T. Strong, Novon 3(2): 202. 1993. Fig. 3f.
Scirpus purshianus Fernald, Rhodora 44: 479. 1942.
Scirpus debilis Pursh, Fl. Amer. Sept. 55. 1813, non Lam. 1791.
Schoenoplectus juncoides (Roxb.) Palla ssp. *purshianus* (Fern.) Soják, Čas. Nár. Muz. Odd. Přír. 141(1-2): 62. 1972.

DESCRIPTION. Caespitose. **Culms** glabrous, trigonous, not septate, 3-7 (-10) dm tall, 1.5-3 mm wide. **Leaves** bladeless, or with a few, short, callous-tipped blades on upper sheaths; **sheaths** confined to basal portion of culm, closed, septate, glabrous, the summit acute, short mucronate, the inner band scarious, red-dotted. **Inflorescence** pseudolateral, spikelets in a single, sessile glomerule; **involucral bract** 1, appearing as a continuation of the culm, 0.6-1.2 dm long, callous-tipped; **spikelets** ovoid to cylindric, (1-) 3-8 (-16), 0.5-1 cm long, 3.5-5 mm wide; **scales** orbicular to rounded-ovate, 2.5-3.5 mm long, 2.5-3 mm wide, lustrous, many-nerved, greenish to stramineous or brownish, the indistinct midrib prolonged into a short, acute mucro at the dark brown apex; **stamens** 2; **anthers** narrowly oblong, ca. 1 mm long, with a small, brown, triangular, prickly tip; **style** 2-branched, scaly, with ascending to divergent hairs. **Achene** unequally biconvex, rounded-obovate, 1.7-2.0 mm long, 1-1.5 mm wide, blackish brown, lustrous, pitted; **bristles** 6, light brown, stout, retrorsely barbed the entire length, equalling to exceeding the achene.

FLOWERING AND FRUITING. Late June-July (later in mountains); July-Oct.

DISTRIBUTION. Scattered localities throughout the state, but more frequent in the piedmont (see Harvill et al. 1992); additional county not recorded by Harvill et al. 1992: Bedford Co., *Curtiss 3702* (US); Southwestern Maine, New Hampshire, Vermont, southeastern New York, eastern Pennsylvania, West Virginia, southern Michigan, Wisconsin, Minnesota, south to Georgia, Alabama and Mississippi.

HABITAT IN VIRGINIA. Open swales, pond borders, reservoirs, marshes, springy ditches, and disturbed areas.

DISTINGUISHING FEATURES. See *Sch. smithii.*

DISCUSSION. See *Sch. smithii.*

03. **Schoenoplectus subterminalis** (Torrey) Soják, Čas. Nár. Muz. Odd. Přír. 140(3-4): 127. 1972. Fig. 4e.

Scirpus subterminalis Torrey, Fl. N. Middle United States 47. 1824.

DESCRIPTION. Submersed or emersed rhizomatous perennial. **Rhizomes** soft, slender, sometimes bearing small tubers. **Culms** terete, filiform, septate, 0.2-1.4 m long. **Leaves** numerous, elongate and flaccid in submersed plants, few, short or wanting, and stiff in emersed plants; **sheaths** open, whitish, friable, the adaxial summit with a short ligule, 0.4-0.5 mm long; **blades** crescentform-capillary or conduplicate, septate, 0.5-1 mm wide, to 5 dm long. **Inflorescence** pseudolateral, with a single, sessile spikelet; **involucral bract** 1, channeled, 1-6 cm long, callous-tipped, appearing as a continuation of the culm; mature **spikelet** ovoid to lanceolate, 5-15 mm long, 4-7 mm wide; **scales** ovate-lanceolate, acute, membranaceous, 4-6 mm long, 2-2.2 mm wide, green to pale brown with scarious margins, the green midrib mucronate at apex; **stamens** 3; **anthers** narrowly oblong, 3-4 mm long, with a rounded to bulbous, thickened appendage at tip; **style** somewhat flattened, 3-branched, the branches scaly, with ascending to divergent hairs. **Achene** trigonous-obovoid, 3-3.5 mm long, 2 mm wide, smooth, lustrous, becoming yellowish to olive-brown, with a 0.5-0.7 mm long beak at apex; **bristles** 6, reddish, retrorsely barbed, unequal, shorter than to equaling or slightly exceeding the achene beak.

FLOWERING AND FRUITING. June; July and Aug.

DISTRIBUTION. Rare in Augusta and Caroline counties and the City of Virginia Beach (see Harvill et al. 1992); Newfoundland to Ontario, south to Virginia, South Carolina, and eastern Georgia; westward to northern Ohio, northern Indiana, northern Illinois, Missouri, southern Alaska to southern Oregon, northwestern Montana, Wyoming, northern Idaho, and California. An isolated station occurs in Utah. This species is currently listed as S1 (extremely rare in the state) by the Virginia Department of Conservation and Recreation (1993).

HABITAT IN VIRGINIA. Pond margins and fresh to brackish marshes. Two growth forms exist: submersed or stranded (leaves filiform and flaccid) and emersed (leaves conduplicate and stiff).

DISTINGUISHING FEATURES. This species is readily distinguished by its single, sessile spikelet subtended by an elongate involucral bract appearing like a continuation of the culm; terete culms; open sheaths; and crescentform-capillary leaf blades.

DISCUSSION. Fernald (1950) described *Schoenoplectus subterminalis* as having two forms: f. *subterminalis* (plants submersed or stranded, the leaves capillary and flaccid with elongate blades) and f. *terrestris* (plants emersed, the leaves firm and upright, few, short or wanting).

04. **Schoenoplectus torreyi** (Olney) Palla, Allg. Bot. Z. Syst. 17, Beilage 10/12: 3. 1912. Fig. 4f.

Scirpus torreyi Olney, Proc. Prov. Frankl. Soc. 1: 32. 1847.

DESCRIPTION. Robust perennial. **Rhizomes** horizontal, elongate, flaccid, brownish, 2-4 mm thick. **Culms** 0.4-1.5 m tall, 3-5 mm wide, trigonous, with concave sides, usually solitary. **Leaves** 2-3, elongate, confined to basal portion of culm; **sheaths** septate, inner band scarious, disintegrating with age, the prominant mid and laterally branching veins remaining, the summit short ligulate at adaxial junction of sheath and blade; **blades** 1.5-4 mm wide, to 1.2 m long, septate, terete or triangular-channeled, rigid or somewhat flaccid in submersed habitats. **Inflorescence** pseudolateral, with a single glomerule of 1-4 spikelets; **involucral bract** 1, erect, appearing as a continuation of the culm, 3-16 cm long; **spikelets** ovoid to narrowly cylindric, cuneate at base, 1-1.8 cm long, 4-7 mm wide; **scales** ovate, 4-7 mm long, 2-3 mm wide, smooth, lustrous, pale brown to golden brown, the green midrib short mucronate at apex; **stamens** 3; **anthers** narrowly oblong to linear, 2.5-4 mm long, with a rounded to bulbous, thickened appendage at tip; **style** somewhat flattened, 3-branched, the branches glabrous. **Achene** trigonous-obovoid, 3.4-5 mm long, 2-2.2 mm wide, smooth, yellowish to olive-brown, with a 0.5-0.7 mm long beak at apex; **bristles** 6, retrorsely barbed, slightly shorter than to exceeding the achene.

FLOWERING AND FRUITING. Late June-July; late July-Sept.

DISTRIBUTION. Known only from Agusta and Rockingham counties in Virginia (see Harvill et al. 1992); New Brunswick to Manitoba, south to southern New England, Long Island, Pennsylvania, Virginia, Kentucky, Illinois, Missouri, and Nebraska. This species is currently listed as a candidate for listing as threatened or endangered by the Virginia Department of Conservation and Recreation (1993).

HABITAT IN VIRGINIA. Mountain ponds.

DISTINGUISHING FEATURES. *Sch. torreyi* can be distinguished by its 1-4, sessile, pale brown to golden brown, lustrous spikelets which are cuneate at base; sheaths with scarious inner band, which at maturity disintegrates, the prominent mid and laterally branching veins remaining; and elongate, triangular-channeled leaf blades.

05. **Schoenoplectus etuberculatus** (Steud.) Soják, Čas. Nár. Muz. Odd. Přír. 140(3-4): 127. 1972. Fig. 4c.

Rhynchospora etuberculata Steud., Syn. Pl. Glumac. 2: 142. 1855.

Scirpus etuberculatus (Steud.) Kuntze, Revis. Gen. Pl. 2: 758. 1891.

DESCRIPTION. Colonial perennial. **Rhizomes** horizontal, elongate, reddish, 1-3 mm thick. **Culms** 1-2 m tall, trigonous, soft, easily compressed. **Leaves** 1-3, confined to basal portion of culm; **sheaths** with narrow, scarious margins; **blades** 1-3, 2-12 mm wide, to 8 dm long, septate, triangular-channeled or ribbon-like in submersed blades, excentric at tip. **Inflorescence** pseudolateral, anthelate, with 4-16 spikelets; **involucral bracts** 1-3, the lowest appearing as a continuation of the culm, triangular, 1-2.5 dm long, excentric at tip; **rays** 5-9, somewhat flattened to obtusely trigonous, glabrous, scabrous along margins; **spikelets** narrowly ovoid to cylindric, cuneate at base, 1-2.5 cm long, 4-8 mm wide; **scales** oblong-ovate, acute to cuspidate, sagittate at base, 4.5-6 mm long, 2.2-3 mm wide, smooth, green to pale brown, the green midrib ending in a short cusp at apex; **stamens** 3; **anthers** narrowly oblong to linear, 2.5-3 mm long, tipped by a triangular-ovate appendage; **style** somewhat flattened, 3-branched, the branches glabrous, with minute scales. **Achene** plano-convex, obovate, 3-4 mm long, 1.9-2.2 mm wide, with a subulate beak 0.8-1 mm long, smooth and shining, brownish; **bristles** 6, reddish, with antrorse to divergent barbs, unequal, slightly shorter than to equaling or exceeding the achene.

FLOWERING AND FRUITING. Late July-Aug.; Aug.-Sept.

DISTRIBUTION. Historically known from only one locality in Virginia: Princess Anne County, shallow water, NW branch of Salt Pond, *L.F. Randolph & F.R. Randolph 462*, 29 June 1922 (GH); Florida to Louisiana, north to Delaware and Missouri, disjunct to Rhode Island. This species is currently listed as S1 (extremely rare in the state) by the Virginia Department of Conservation and Recreation (1993).

DISTINGUISHING FEATURES. *Sch. etuberculatus* can be distinguished by its triangular-channeled, emergent leaf blades, and involucral bracts with excentric apex; flaccid, ribbon-like submersed leaf blades; and open, anthelate, pseudolateral inflorescence of 4-16 large (1-2.5 cm long, 4-8 mm wide) spikelets.

06. **Schoenoplectus americanus** (Pers.) Volkart ex Schinz & Keller, Fl. Schweiz Ed. 2: 75. 1905. Figs. 3c, 8c and d.

Scirpus americanus Pers. Syn. Pl. 1: 68. 1805.

Scirpus Olneyi A. Gray ex Engelm. & A. Gray, Boston J. Nat. Hist. 5: 238. 1845.

Schoenoplectus olneyi (A. Gray) Palla, Bot. Jahrb. Syst. 10: 299. 1888.

DESCRIPTION. Robust perennial. **Rhizomes** horizontal, elongate, 3.5-5 mm thick, reddish. **Culms** 0.3-2 m tall, 4-10 mm wide, sharply trigonous, wing-angled, with deeply concave sides, red to red-tinged near base. **Leaves** 1-2, blade-bearing or the lower bladeless, confined to basal portion of culm; **sheaths** septate, with a short ligule ca. 1 mm long at adaxial junction of sheath and blade, the inner band firm with a U- or V-shaped notch at orifice; **blades** septate, 1-15 mm long, 1-4 mm wide. **Inflorescence** pseudolateral, with a single glomerate cluster of (3-) 5-12 spikelets; **involucral bract** 1, lance-triangular, obtuse to subacute, 1-2 (-3.5) cm long, appearing as a continuation of the culm, glabrous; **spikelets** ovoid, narrowly ovoid or ellipsoid, obtuse to subacute at apex, 5-10 (-20) mm long, 4-7 mm wide; **scales** broadly ovate to orbicular, 2.5-3.2 mm long, 2-2.5 mm wide, light-brown to reddish brown, scarious-margined, the green to yellowish midrib prolonged as a short awn, shorter than to equaling the shallowly emarginate apex; **stamens** 3; **anthers** narrowly oblong, 2-2.5 mm long, with very short, blunt, minutely bearded appendage at tip; **style** straplike, 2- (sometimes 3-) branched, the branches glabrous, minutely scaly. **Achene** plano-convex, suborbicular to broadly obovate, 2-2.5 mm long, 1.6-2.2 mm wide, smooth, brownish to grayish brown; **bristles** 1-6, reddish, with downcurved-retrorse barbs, shorter than to equaling the achene.

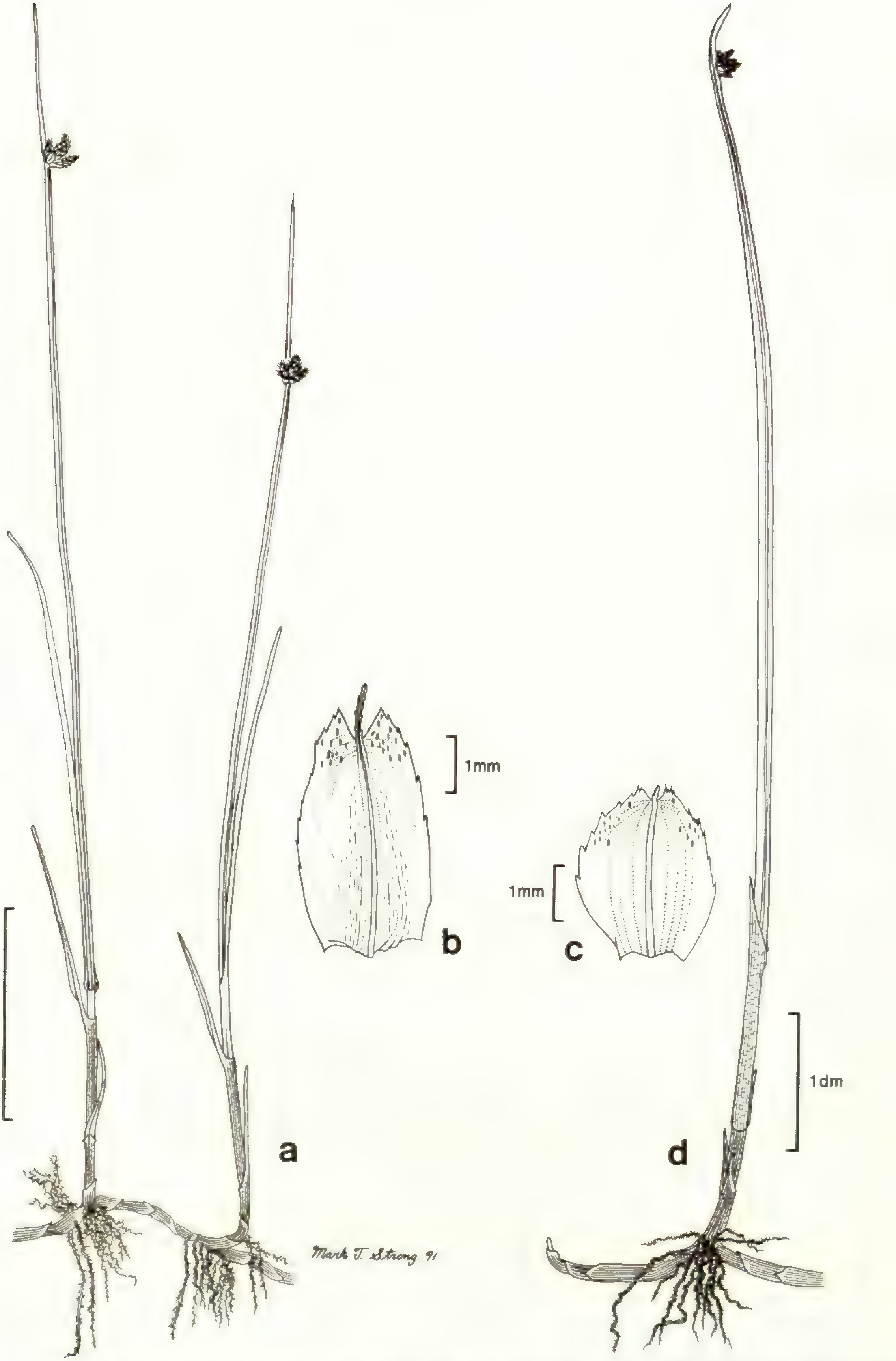
FLOWERING AND FRUITING. Late May-June; late June-Sept.

DISTRIBUTION. Restricted to the coastal plain of Virginia (see Harvill et al. 1992); Florida to Mexico north to Nova Scotia, northern Ohio, southern Michigan, western Nova Scotia, Missouri, Idaho, and Oregon; West Indies, Central America & South America.

HABITAT IN VIRGINIA. Brackish to saline marshes.

DISTINGUISHING FEATURES. This species is closely related to *Sch. pungens* but can be distinguished from it by its stout, sharply trigonous, wing-angled culms with deeply concave sides (4-10 mm wide); short involucral bract (1-2 (-3.5) cm long); shorter leaf blades (1-15 mm long); scales with awns shorter than to equaling the shallowly cleft apex; shorter achenes (2-2.7 mm long); and broader, strap-like bristles with downcurved teeth.

Schoenoplectus pungens differs in having narrower culms (1-5 mm wide); longer involucral bracts (2-15 cm long); longer leaf blades (0.5-4 dm long); scales with awns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Mark T. Strong 91

FIG. 8. a and b, *Schoenoplectus pungens*. (a) habit. (b) spikelet scale. c and d, *Schoenoplectus americanus*. (c) spikelet scale. (d) habit.

exceeding the deeply cleft, emarginate apex; longer achenes (2.5-3.0 (-3.2) mm long); and narrower hypogynous bristles with retrorse teeth.

NOMENCLATURE. This species has been treated in many North American floras as *Scirpus olneyi* Gray, e.g., Small (1933), Beetle (1947), Fernald (1950), Gleason (1952), Gleason and Cronquist (1963), and Radford et al. (1968). Schuyler (1974), found that the type specimen of *Scirpus americanus* Persoon was conspecific with plants usually treated as *Scirpus olneyi* and the type specimen of *Scirpus pungens* Vahl was conspecific with plants usually treated as *Scirpus americanus*. Thus the correct name for plants previously treated as *Scirpus olneyi* (*Schoenoplectus olneyi*) is *Scirpus americanus* (*Schoenoplectus americanus*), and the correct name for plants previously treated as *Scirpus americanus* (*Schoenoplectus americanus*) is *Scirpus pungens* (*Schoenoplectus pungens*).

DISCUSSION. In Virginia, *Schoenoplectus americanus* occurs only on the coastal plain and is primarily restricted to tidal saline marshes in the lower Chesapeake Bay and outer coastal plain, whereas *Schoenoplectus pungens* is more widespread and occurs in a variety of fresh to saline habitats, most notably on wet or inundated sandy shores of inland and tidal rivers, creeks, and beaches. Generally these two species are isolated ecologically, but apparent hybrids occasionally occur in intermediate habitats where they are sometimes abundant (Schuyler pers. comm., 1991). The resulting hybrids tend to be intermediate in characters.

07. **Schoenoplectus pungens** (Vahl) Palla, Bot. Jahrb. Syst. 10: 299. 1888. Figs. 3d, 8a, b. *Scirpus pungens* Vahl, Enum Pl. 2: 255. 1805 (see Schuyler, Rhodora 76: 51-52. 1974, *Scirpus americanus* Persoon, misapplied).

DESCRIPTION. Robust perennial. **Rhizomes** horizontal, elongate, stout, 4-10 mm thick. **Culms** sharply trigonous, frequently with concave sides above, 0.3-1.5 m tall, 1-5 mm wide. **Leaves** 2-4, confined to basal portion of culm; **sheaths** short ligulate at adaxial junction of sheath and blade, septate, the inner band firm with a scarious, red-dotted orifice, concave at apex; **blades** linear-elongate, sharp-pointed, 0.5-4 dm long, 2-9 mm wide, dorsally to laterally compressed, becoming sub-trigonous near apex. **Inflorescence** pseudolateral, a single glomerate cluster of 1-6 (-8) spikelets; **involucral bract** 1, acuminate, 2-15 cm long, appearing as a continuation of the culm; **spikelets** ovoid to subcylindric, 0.5-2 cm long, 3-5 mm wide; **scales** ovate, 4-6 mm long, 2-2.5 mm wide, reddish-brown, the green midrib prolonged into a short, scabrous awn which exceeds the deeply emarginate apex; **stamens** 3; **anthers** narrowly oblong to linear, ca. 3 mm long, with fringed appendage at tip; **style** straplike, 2- (sometimes 3-) branched, the branches glabrous, minutely scaly. **Achene** plano-convex, obovate, 2.5-3.0 (-3.2) mm long, 1.5-2 mm wide, smooth, olivaceous to brown; **bristles** 3-6, retrorsely barbed, reddish, sometimes rudimentary, less than 3/4 the length of the achene.

FLOWERING AND FRUITING. Mid May-June; June-Sept.

DISTRIBUTION. Scattered localities throughout the state, but more frequent on the coastal plain (see Harvill et al. 1992); additional county not recorded by Harvill et al. 1992: Loudoun Co., *Smith 102* (US); Florida to Texas, north to Newfoundland, Quebec, southern Ontario, Michigan, Wisconsin, Minnesota and Nebraska; South America, Europe, Australia, and New Zealand.

HABITAT IN VIRGINIA. Tidal shores along rivers, sandy river banks and shores, and creeks.

DISTINGUISHING FEATURES. See *Sch. americanus.*
NOMENCLATURE. See *Sch. americanus.*
DISCUSSION. See *Sch. americanus.*

08. **Schoenoplectus validus** (Vahl) A. & D. Löve, Bull. Torrey Bot. Club 81: 33. 1954. Figs. 3a, 9a-c.
Scirpus validus Vahl, Enum. Pl. 2: 268. 1805.
Scirpus validus Vahl var. *creber* Fern., Rhodora 45: 282. 1943.
Scirpus lacustris L. ssp. *validus* (Vahl) Koyama, Canad. J. Bot. 40: 927. 1962.
Schoenoplectus lacustris L. ssp. *creber* (Fern.) A. & D. Löve, Taxon 30(4): 849. 1981.

DESCRIPTION. Robust perennial. **Rhizomes** stout, scaly, horizontal, elongate, 0.7-1.5 cm thick, reddish. **Culms** terete, easily compressed, 0.5-3 m tall, 0.3-2 cm wide at base, forming in a row along the rhizome. **Leaves** 3-5 bladeless sheaths, short mucronate or the uppermost with short blades, confined to basal portion of culm; **sheaths** with a short, firm ligule, ca. 1.5 mm long, borne at adaxial junction of sheath and blade, the margins of the sheath scarious above, gradually narrowing towards base to V-shaped orifice; **blades** 1-2 on upper sheaths, 2-10 cm long, dorsally flattened, thickened towards summit with cartilaginous tip. **Inflorescence** pseudolateral, anthelate, compound to partially decompound, pendulous, the numerous spikelets solitary or in small glomerules of 2-3 (-5) at ray tips; **involucral bracts** 2-3, the lowest one erect, appearing as a continuation of the culm, the others membranaceous, scale-like; **rays** flat, to somewhat obtusely angled, glabrous, scabrous on margins, arching to pendulous; **spikelets** ovoid to ovoid-ellipsoid, acute, 5-7 (-9) mm long, 3-4 mm wide; **scales** ovate to elliptic, 2.5-3.2 mm long, 1.8-2.2 mm wide, reddish-brown, erose-ciliate, with scarious margins, the green midrib prolonged as a short, straight, scabrous awn at the emarginate apex; **stamens** 3, marcescent; **anthers** narrowly oblong, 1-2 mm long, tipped by a triangular-ovate appendage; **style** straplike, 2 or 3 branched, the branches glabrous, with minute scales. **Achene** plano-convex, broadly ovate, 1.7-2.3 mm long, 1.3-1.5 mm wide, smooth, grayish to drak-brown; **bristles** 6, slender, stiff, retrorsely barbed, red-brown, shorter than to equaling or slightly exceeding the achene.

FLOWERING AND FRUITING. Late May-June; June-Sept.

DISTRIBUTION. Widespread throughout the state (see Harvill et al. 1992); additional counties not recorded by Harvill et al. 1992: Alleghany Co., *Stevens 390* (FARM), Patrick Co., *Harvill & Harvill 29863* (FARM), and Northumberland Co., *Ruth s.n.* (US); Newfoundland to central Alaska, south to Florida and California; Mexico, Central America, West Indies, South America, Eurasia, Australia, New Zealand, and Polynesia.

HABITAT IN VIRGINIA. Tidal shores of rivers, marshy meadows, swales, pond borders, and bottomland swamps.

DISTINGUISHING FEATURES. *Sch. validus* is closely related to *Sch. acutus* but can be distinguished from the latter by its shorter spikelets (5-7 (-9) mm long) that are solitary or in clusters of 2-3 at ray tips and shorter scales (2.5-3.2 mm long) with short, nearly straight awns, whereas *Sch. acutus* has longer spikelets (6-15 mm long) which are in glomerules of 3-7 at ray tips and longer scales (3.5-4 mm long) with an elongate, usually contorted, scabrous awn.

Smith (1969) found that these two species could be separated by the number and size of internal air spaces in the upper 1/4 of the culm. For *Sch. validus*, there were 2 to 4 internal air spaces in a cross section diameter, these averaging 1.0-2.5 mm wide, whereas for *Sch.*

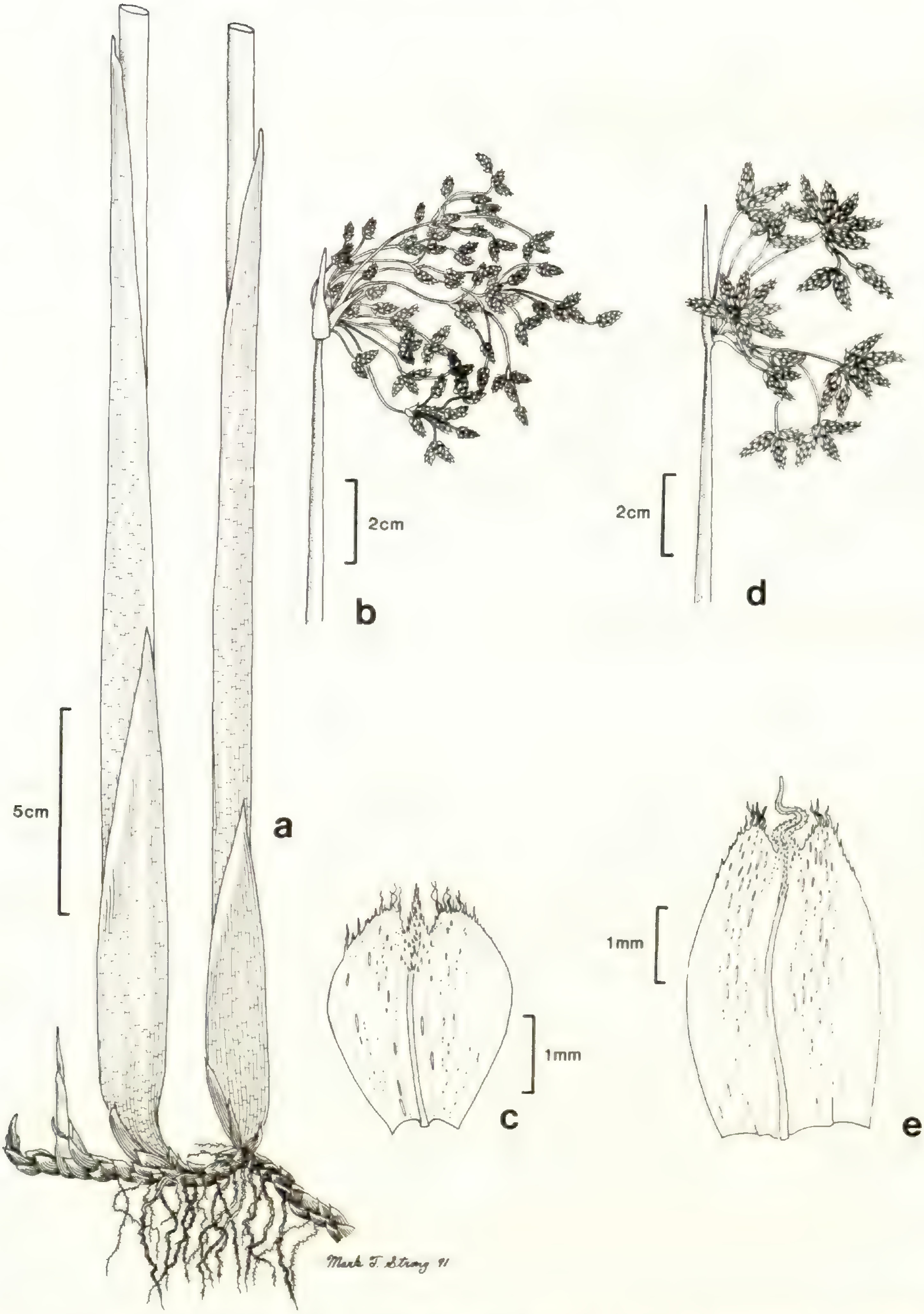
5cm
a
2cm
b
2cm
d
1mm
c
1mm
e
Mark T. Strong 91

FIG. 9. a-c, *Schoenoplectus validus.* (a) rhizome and lower portion of culm. (b) inflorescence. (c) spikelet scale. d and e, *Schoenoplectus acutus.* (d) inflorescence. (e) spikelet scale.

acutus, there were 9-14 spaces averaging 0.3-0.5 mm wide.

DISCUSSION. Hybridization between these two species in northern Michigan, Wisconsin, Iowa, and North Dakota primarily occurs in areas of human or natural disturbance. Those populations in undisturbed sites have different ecological tolerance ranges and as a result of this physical isolation, hybridization does not occur. However, where tolerance ranges overlap and mixed populations occur, particularly in parts of western North America, the species may be isolated by other factors or extensive hybridization may obscure the morphological boundaries between the species (Smith, 1969).

09. **Schoenoplectus acutus** (Muhl. ex Bigelow) A. & D. Löve, Bull. Torrey Bot. Club, 81: 33. 1954. Figs. 3b, 9d and e.
Scirpus acutus Muhl. ex Bigelow, Fl. Boston 15. 1814.
Schoenoplectus lacustris ssp. *acutus* (Muhl. ex Bigelow) A. & D. Löve, Taxon 30(4): 849. 1981.

DESCRIPTION. Robust perennial. **Rhizomes** stout, scaly, horizontal, elongate, 0.5-1.5 cm thick, pale brown to brown. **Culms** firm, terete, 1-3 m tall, to 2 cm wide at base. **Leaves** 3-5 short-mucronate, bladeless sheaths or the uppermost with short blades, confined to the basal portion of the culm; **sheaths** lustrous brown near base, septate, with a short, scarious ligule borne at adaxial junction of sheath and blade, the ventral band of the uppermost leaves scarious, veiny, with divergently branching midvein, forming a truncate to concave orifice at apex; **blades** 1-2 on upper sheaths, 2-15 cm long. **Inflorescence** pseudolateral, anthelate, the spikelets rarely solitary, usually in glomerules of 3-7 at ray tips; **involucral bracts** 2-3, the lowest erect, appearing as a continuation or the culm, the others membranous, scale-like; **rays** flat to somewhat obtusely angled, glabrous, scabrous on margins, divergent to subpendulous; **spikelets** oblong-ovoid, 6-15 mm long, 2-5 mm wide, acute; **scales** 3.5-4 mm long, 2 mm wide, brown to reddish-brown, erose-ciliate on margins, the green midrib often prolonged into a contorted, scabrous awn at apex; **stamens** 3; **anthers** narrowly oblong, 1-2 mm long, tipped by a triangular-ovate appendage; **style** straplike, 2 or 3 branched, the branches glabrous, minutely scaly. **Achene** plano-convex, ovate to ovate-elliptic, 2-2.8 mm long, 1.5-2 mm wide, smooth, pale brown to grayish-brown or deep brown; **bristles** 2-6, slender, stiff, retrorsely barbed, reddish, shorter than to equaling the achene.

FLOWERING AND FRUITING. June to early Aug.; Aug.-Oct.

DISTRIBUTION. Known only from Augusta and Arlington counties in Virginia; Newfoundland to British Columbia, south to Nova Scotia, New England, northern New Jersey, Virginia, North Carolina, Pennsylvania, Ohio, Illinois, Tennessee, Missouri, Oklahoma, Texas, New Mexico, Arizona, and California. This species is listed as S2 (very rare in the state) by the Virginia Department of Conservation and Recreation (1993).

HABITAT IN VIRGINIA. Calcareous wet meadows in the mountains and fresh to brackish tidal marshes on the coastal plain.

DISTINGUISHING FEATURES. See *Sch. validus*.

DISCUSSION. See *Sch. validus*.

10. **Schoenoplectus fluviatilis** (Torrey) M. T. Strong, Novon 3(2): 203. 1993. Figs. 4d, 10c.
Scirpus maritimus L. ß ? *fluviatilis* Torrey, Ann. Lyceum Nat. Hist. New York 3: 324. 1826.
Scirpus fluviatilis (Torrey) A. Gray, Manual Bot. N. United States: 527. 1848.

Bolboschoenus fluviatilis (Torrey) Soják, Čas. Nár. Muz. Odd. Přír. 141: 62. 1972.

DESCRIPTION. Robust perennial. **Rhizomes** horizontal, elongate, 4-7 mm wide. **Culms** sharply trigonous, 0.7-2 m tall, to 1.5 cm wide at base, arising from hard, swollen, tuberous enlargements to 2 cm thick. **Leaves** 5-9, nodes extending up culm to above middle; **sheaths** firm, faintly septate, eligulate, the orifice with a U-shaped, rounded or truncate contraligule with short-scarious apex; **blades** 7-20 mm wide, to 8 dm long, smooth to weakly scabrous on margins and midvein beneath. **Inflorescence** a spreading, compound, umbel-like corymb, anthelate, the lowest leaf-like bract erect at anthesis, the inflorescence appearing pseudolateral, at maturity spreading and appearing terminal; **involucral bracts** 5-6, elongate, leaf-like, much exceeding the inflorescence; **rays** 5-12, elongate, up to 12 cm long, glabrous, somewhat flattened to obtusely angled or subterete, spreading, scabrous on margins, recurved at maturity, the spikelets solitary or in glomerules of 2-5 at ray tips; **spikelets** oblong-ovoid to ellipsoid, cuneate at base, 1.5-2.5 (-4) cm long, 0.7-1 cm wide; **scales** oblong-ovate to elliptic, 0.7-1 cm long (excluding awn), 3.5-6 mm wide, pale brown, puberulent, with erose to slightly lacerate margins, the pale green midrib prolonged as a recurved awn 2-4 mm long, exceeding the notched apex; **stamens** 3; **anthers** narrowly oblong to linear, 3-6 mm long, with an antrorsely barbed, linear appendaged tip; **style** angled to somewhat flattened, 3-branched, the branches glabrous, minutely scaly. **Achene** trigonous, pyriform to obovoid, 4-5 mm long, 2.2-2.5 mm wide, prominently beaked, pale brown; **bristles** 6, persistent, retrorsely barbed, about equaling or slightly exceeding the achene.

FLOWERING AND FRUITING. June to early July; July-Aug.

DISTRIBUTION. Occurs in Fairfax, Giles, and King George counties in Virginia; Western New Brunswick to Saskatchewan and Washington, south to New England, Delaware, Maryland, Virginia, Pennsylvania, Ohio, Indiana, Illinois, Missouri, Kansas, New Mexico, and California; Asia, Australia, New Zealand, and Japan. This species is listed as S1 (extremely rare in the state) by the Virginia Department of Conservation and Recreation (1993).

HABITAT IN VIRGINIA. Fresh water tidal shores and marshes of large river systems on the coastal plain, occurrring infrequently along shorelines of inland rivers.

DISTINGUISHING FEATURES. *Schoenoplectus fluviatilis* can be distinguished from the related *Sch. robustus* and *Sch. novae-angliae* by its sharply trigonous, pyriform to obovoid achenes which taper at the apex to a prominent beak; 6 persistent bristles that equal or slightly exceed the achene; open, spreading inflorescence with elongate primary rays; cuneate base of the spikelets; and pale brown scales. *Schoenoplectus robustus* has lenticular or plano-convex, obovate, smooth, lustrous, blackish brown achenes which are truncate at apex, abruptly differentiated into a short beak; caducous bristles; congested inflorescence with short primary rays; and ovoid spikelets with truncate base, 1.3-3 cm long, or in forma *protrusus* Fernald, 3-6 cm long. *Schoenoplectus novae-angliae* differs in having plano-convex, obovate, whitish or olive brown achenes which are rounded at the summit, gradually tapering into a prominent beak; 1-6 persistent bristles which are shorter than to equaling the achene; and elongate spikelets ((1.5-) 2-6 cm long).

11. **Schoenoplectus robustus** (Pursh) M. T. Strong, Novon 3(2): 203. 1993. Figs. 4a, 10a.
Scirpus robustus Pursh, Fl. Amer. Sept. 1: 56. 1816. (based on *Scirpus maritimus* ß *macrostachyos* Michaux, Fl. Amer. 1: 32. 1803, non *Scirpus macrostachyos* Lam., Tabl. Encycl. 1: 142. 1791).

Scirpus maritimus var. *robustus* (Pursh) Kük., Repert. Spec. Nov. Regni. Veg. 23: 200. 1926.
Bolboschoenus robustus (Pursh) Soják, Čas. Nár. Muz. Odd. Přír. 141: 63. 1972.

DESCRIPTION. Robust perennial. **Rhizomes** horizontal, elongate, 3-6 mm thick. **Culms** sharply trigonous, 0.7-1.5 m tall, 5-9 mm wide near base, arising from hard, swollen, tuberous enlargements. **Leaves** 4-9, the nodes extending above mid portion of culm; **sheaths** septate, eligulate, the orifice with a short, subscarious, acute to rounded or on lower sheaths, convex contraligule, prominently veined below; **blades** 4-12 mm wide, up to 7 dm long, smooth to weakly scabrous on margins. **Inflorescence** a congested, compound, umbel-like corymb, anthelate, the lowest leaf-like bract erect at anthesis, the inflorescence appearing pseudolateral, at maturity spreading and appearing terminal; **involucral bracts** 3-5, to 4 dm long, leaf-like; **rays** short, terete to obtusely angled, smooth, the spikelets in a basal mass, solitary, or 2-5 at ray tips; **spikelets** (1-) 3-11 (-20), ovoid to narrowly ovoid, or rarely cylindrical, blunt to rounded at tip, truncate at base, 1.3-3 (-6) cm long, 0.8-1.2 cm wide; **scales** oblong-ovate to elliptic, 5-7 mm long (excluding awn), 3-4 mm wide, reddish-brown to rufescent, puberulent, the narrow, pale brown midrib prolonged as a recurved awn, exceeding the notched apex, 1-3 mm long; **stamens** 3; **anthers** narrowly oblong to linear, 2-3.5 mm long, with acute, antrorsely barbed appendage at tip; **style** straplike, 3-branched, the branches glabrous. **Achene** lenticular or plano-convex, obovate, truncate at apex, abruptly short-beaked, 3-3.5 mm long, 2-3 mm wide, reddish brown to blackish brown at maturity, lustrous; **bristles** none or caducous, or occasionally 1-6 persist at base of achene, retrorsely barbed, 1/3 to 3/4 the length of the achene.

FLOWERING AND FRUITING. Late May-June; late June-Sept.

DISTRIBUTION. Primarily restricted to the coastal plain in Virginia (see Harvill et al. 1992); Florida to eastern Mexico, northern Georgia, South Carolina, North Carolina, Virginia, Maryland, New Jersey, Pennsylvania, Long Island, New York, and Massachusetts, west to California.

HABITAT IN VIRGINIA. Brackish to saline tidal marshes, salt springs.

DISTINGUISHING FEATURES. see *Sch. fluviatilis*.

12. **Schoenoplectus novae-angliae** (Britt.) M. T. Strong, Novon 3(2): 203. 1993. Figs. 4b, 10b.
Scirpus novae-angliae Britt. Ill. Fl. N. U.S. 3: 509. 1898.
Scirpus maritimus y *cylindricus* Torr., Ann. Lyceum Nat. Hist. New York 3: 325. 1836.
Scirpus cylindricus (Torr.) Brit., nom. illeg. Trans. N.Y. Acad. Sci. 11: 79. 1892. non *Scirpus cylindricus* (Vahl) Lam., Encyl. Method. Vol. 5 (suppl.): 101. 1817.
Scirpus campestris var. *novae-angliae* (Britt.) Fern., Rhodora 8: 136. 1906.
Scirpus robustus var. *novae-angliae* (Britt.) Beetle, Amer. J. Bot. 29: 82. 1942.
Scirpus subterminalis var. *cylindricus* (Torr.) Koyama, Canad. J. Bot. 40: 930. 1962.

DESCRIPTION. Robust perennial. **Rhizomes** horizontal, elongate. **Culms** 0.7-1.5 m tall, to 9 mm wide at base, smooth, arising from hard, tuberous enlargements. **Leaves** 4-7, nodes extending above mid portion of culm; **sheaths** glabrous, eligulate, the orifice with a short, scarious, convex to truncate or concave-tipped contraligule; **blades** 6-15 mm wide, to 7 dm long, smooth to weakly scabrous on margins and midvein beneath. **Inflorescence** a congested to semi-open, compound, umbel-like corymb, anthelate, the lowest leaf-like bract erect at anthesis, the inflorescence appearing pseudolateral, at maturity spreading and appearing

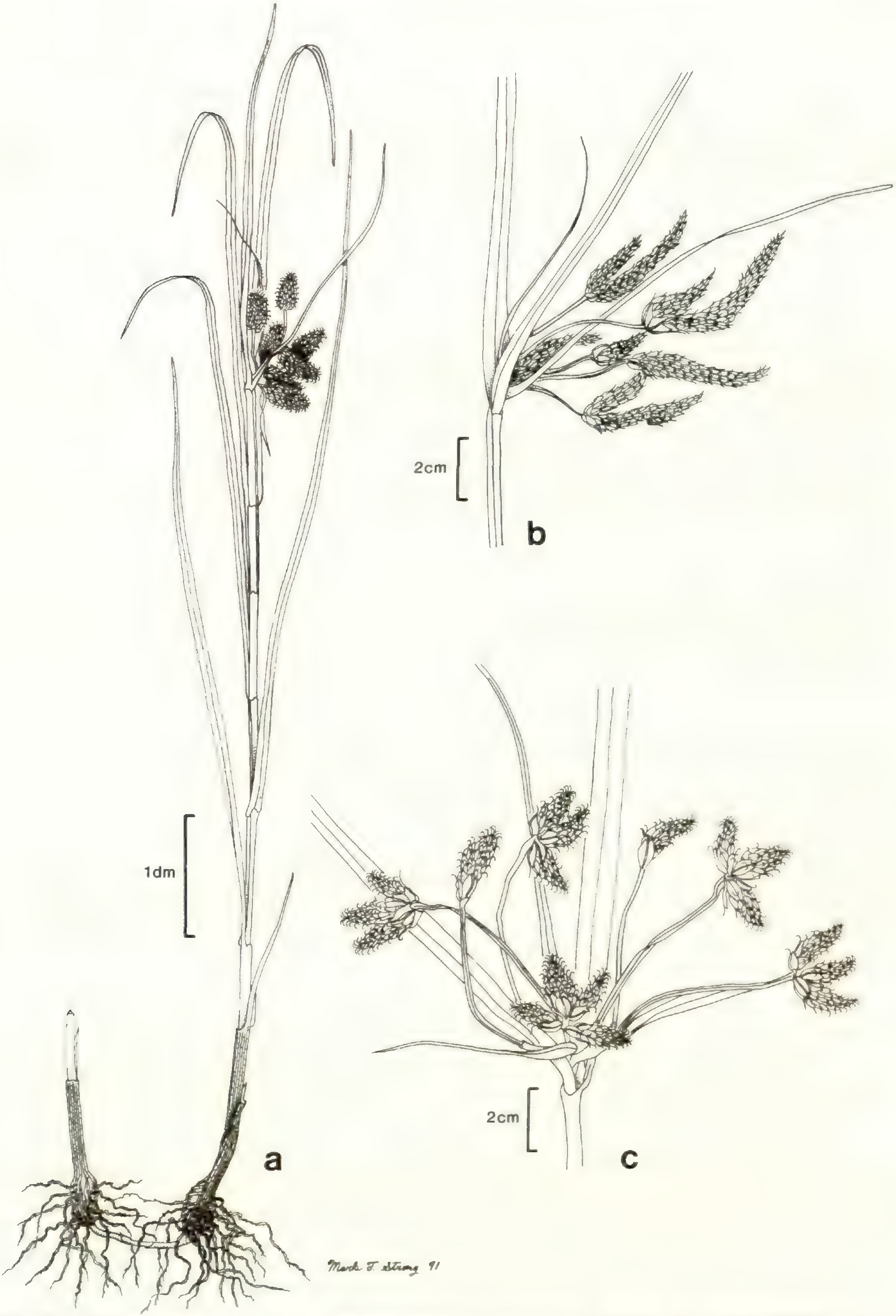
2cm
b
1dm
2cm
c
a
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FIG. 10. (a) *Sch. robustus* (habit). (b) *Sch. novae-angliae* (inflorescence). (c) *Sch. fluviatilis* (inflorescence).

terminal; **involucral bracts** 3-5, leaf-like, up to 3 dm long; **rays** short, or few elongate, smooth, terete to somewhat flattened or obtusely angled, the spikelets solitary or 2-5 at ray tips; **spikelets** 15-40, narrowly oblong, elongate, (1.5-) 2-5 cm long, 5-8 mm wide; **scales** 7-8 mm long, 3.5-5 mm wide, pale brown to reddish brown, puberulent, the narrow, pale brown midrib prolonged as a recurved awn, 1-4 mm long, exceeding the notched apex; **stamens** 3; **anthers** narrowly oblong to linear, 3-3.5 mm long, with acute, antrorsely barbed appendage at tip; **style** straplike, 3-branched, the branches scaly with ascending to divergent hairs. **Achene** plano-convex, obovate, rounded at summit, gradually tapering into a beak, 3.5-4 mm long, 2.7-3.3 mm wide, whitish to olive brown; **bristles** 1-6, persistent, retrorsely barbed to base, shorter than to equaling the achene.

FLOWERING AND FRUITING. Late June-July; July-Sept.

DISTRIBUTION. Occurs in Charles City, James City, New Kent, Prince William, Stafford, and Surry counties on the coastal plain of Virginia; coastal plain of eastern North America from Maine to Georgia.

HABITAT IN VIRGINIA. Fresh to brackish tidal marshes.

DISTINGUISHING FEATURES. See *Sch. fluviatilis.*

NOMENCLATURE. In North American floras, *Sch. novae-angliae* has gone under a variety of names. Beetle (1947) treated it as *Scirpus robustus* var. *novae-angliae.* Fernald (1943) considered it to be a variety of typical European *Scirpus maritimus.* He cited *Scirpus novae-angliae* as a synonym, but this synonym was misapplied, the type of his variety being conspecific with *Scirpus paludosus* Nels. (Schuyler 1975a). Schuyler (1975a) found *S. novae-angliae* to be a distinct North American species citing both morphological as well as ecological evidence (see discussion below), but the name he applied to it (*S. cylindricus* (Torr.) Britt., (1898)) is a later homonym of *S. cylindricus* (Vahl) Lam. (1817). The earliest name for this plant that can be retained is *S. novae-angliae* Britton.

DISCUSSION. *Schoenoplectus novae-angliae* is isolated ecologically from other species of tuberous bulrushes in North America. It is restricted to brackish tidal marshes and shores along the Atlantic coast. It is primarily found in the brackish transition zone between the upper fresh waters (where *Sch. fluviatilis* occurs) and the lower saline waters (where *Sch. robustus* usually occurs) of tidal river systems. This upstream-downstream zonation pattern has been observed by Schuyler (1975a) on the Delaware River in Delaware, Pennsylvania, and New Jersey, and on the Kennebec River in Maine, and by me on the Potomac River in Virginia.

EXCLUDED SPECIES

Lipocarpha rehmanii (Ridley) Goetghebeur (*Scirpus rehmanii* Ridley). This, a species of tropical Africa, ranges from Kenya to South Africa and Madagascar (Goetghebeur and Vanden Borre 1989). Reed (1964) found this plant growing in wet areas on chrome ore piles in Newport News (*Reed 44058*, 7 Aug. 1959 (US)). Apparently, the ore piles are now gone (Reed pers. comm. 1991). Since no recent collections have been made in the state, these plants are doubtfully persisting elsewhere, and at present cannot be considered an established element in Virginia's flora.

ACKNOWLEDGMENTS

I thank the following people for providing specimens and assistance regarding this study: Ted R. Bradley (GMUF), Alton M. Harvill (FARM), J. Christopher Ludwig (Virginia

Department of Conservation and Recreation), Dan H. Nicolson (US), S. Galen Smith (University of Wisconsin, Whitewater), G.C. Tucker (NYS), Donna M.E. Ware (WILLI), and Thomas F. Wieboldt (VPI). Special appreciation goes to Alfred E. Schuyler (PH) for all of his assistance throughout this study, particularly in regards to availability of specimens and manuscript review and preparation, and Carol L. Kelloff for taking the SEM photomicrographs, assisting with manuscript preparation, and her patience. Further thanks are extended to Dorothy Strong and the late Benjamin Strong for their support during this study.

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Bartonia No. 58: 69-73, 1994

Noteworthy Plant Collections from Pennsylvania

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New Pennsylvania county records not mapped in the *Atlas of the Flora of Pennsylvania* (Wherry et al. 1979) were reported in Thompson et al. (1989) for over 1200 plant taxa. Recent collecting by both authors as well as other additions to the Carnegie Museum of Natural History herbarium (CM) have yielded further new distribution records and taxa previously unreported in Pennsylvania. This paper cites specimens for 149 new county records for 110 taxa in 45 plant families. Three taxa are reported as new to the Pennsylvania flora: *Dyssodia papposa* (Asteraceae), *Spiranthes casei* (Orchidaceae), and *Vitis cinerea* var. *baileyana* (Vitaceae).

This paper also includes specimen data for six species not listed in recent works as occurring in Pennsylvania, but which were included in John Miller's (1923) "Flora of Erie County, Pennsylvania." Miller's herbarium was donated to the Carnegie Museum of Natural History in 1988 by the Erie Historical Society and Planetarium. Previous to that, these specimens and Miller's publication had been generally overlooked. Four of these species are apparent waifs, which have not been recollected: *Tidestromia lanuginosa* (Amaranthaceae), *Cirsium undulatum* (Asteraceae), *Ratibida columnifera* (Asteraceae), and *Jacquemontia tamnifolia* (Convolvulaceae). The other two species, *Aster borealis* (Asteraceae) and *Gentianopsis procera* (Gentianaceae), are apparently native to Pennsylvania.

Three additional taxa have now been collected in all Pennsylvania counties bringing that total to 52 taxa (see previous list in Thompson et al. 1989): *Juncus tenuis* (Juncaceae), *Rumex obtusifolius* (Polygonaceae), and *Fragaria virginiana* (Rosaceae).

The following list is arranged alphabetically by family and taxon with nomenclature generally following that of Wherry et al. (1979). Voucher specimens are deposited at CM.

ACANTHACEAE: *Ruellia strepens*—GREENE: Wind Ridge, *Davis & Davis 5405* (Jun 1942), along roadside on bank.

ACERACEAE: *Acer platanoides*—PERRY: NW of Dromgold on PA 850, *Cusick 27833* (Sep 1988), along Sherman Creek; SOMERSET: Somerset, *Cusick & Shelton 28939* (Jun 1990), weedy ground.

AMARANTHACEAE: *Tidestromia lanuginosa*—ERIE: Car Works Yard, *Kuhn s.n.* (Oct 1914); from the Miller Herbarium.

ARACEAE: *Acorus calamus*—ADAMS: 2.2 mi WNW of Gettysburg on US 30, *Thompson & York 6435* (Jun 1989), roadside ditch; FULTON: 1 mi W of Harrisonville on US 30, *Thompson & York 6438* (Jun 1989), ditch through open field. *Arisaema dracontium*—LAWRENCE: ca 0.75 mi S of Pulaski, *Isaac & Isaac 3092* (May 1990), floodplain woods.

ARISTOLOCHIACEAE: *Aristolochia macrophylla* (*A. durior*)—FAYETTE: ca 0.2 mi N of New Geneva, *Isaac 3677* (Sep 1991), along old road grade in forest.

ASCLEPIADACEAE: *Cynanchum nigrum*—CUMBERLAND: 8 km S of Carlisle, *Zanol 75* (Jul 1990).

ASPLENIACEAE: *Asplenium montanum*—INDIANA: ca 1.5 mi SE of Boltz, *Isaac & Isaac 3088* (May 1990), on sandstone outcroppings.

ASTERACEAE: *Artemisia vulgaris*—1.8 mi E of Pithole, *Isaac 3777* (Sep 1991), roadside. *Aster borealis* (= *A. junciformis*; listed in Miller (1923) as *A. junceus*)—ERIE: Tamarack Swamp, *Miller s.n.* (Aug 1903); apparently first PA record, from the Miller Herbarium, additional Erie County populations recently found at Lake Pleasant and Edinboro Lake fen by James Bissell of the Cleveland Museum of Natural History (pers. comm.). *Aster firmus* (= *A. lucidulus*)—FRANKLIN: Michaux State Forest, NW of Old Forge, *Cusick 28608* (Sep 1989), streambank. *Cirsium undulatum*—ERIE: E&P Dock, *Miller s.n.* (Jul 1911); only known PA record, from the Miller Herbarium. *Dyssodia papposa*—FRANKLIN: SW of Newbridge on Pennsylvania Turnpike, *Cusick 27850* (Sep 1988), road berm; first confirmed PA report, Strother (1969) includes PA in generalized distribution map but cites no specimens, well established along interstate highways in Ohio. *Eupatorium rotundifolium*—FRANKLIN: 1.5 km NE of Pond Bank, *Thompson 8004* (Sep 1990), pine woodland. *Hypochoeris radicata*—FOREST: ca 1 mi S of Tionesta, *Isaac 3794* (Oct 1991), along highway. *Lapsana communis*—LAWRENCE: Rose Point, *Isaac & Isaac 3512* (Jul 1991). *Matricaria matricarioides*—GREENE: ca 5 km E of Aleppo, *Thompson & Walck 7174* (May 1990), along road. *Ratibida columnifera*—ERIE: Elevator dock, *Miller s.n.* (Jul 1908); listed in Miller (1923) as *Lepachys columnaris*. *Solidago arguta* ssp. *arguta*—JUNIATA: Tuscarora Mountain, NW of Ickesburg, *Cusick 27821* (Sep 1988), rocky ground. *Solidago purshii*—FAYETTE: 6.2 mi SE of Farmington, *Thompson 1889* (Aug 1984), Markleysburg Bog. *Solidago speciosa*—CLINTON: 4.2 km NNE of Loganton, *Bier s.n.* (Sep 1989), sandy road bank; PERRY: NW of Dromgold on PA 850, *Cusick 27831* (Sep 1988), along Sherman Creek. *Solidago squarrosa*—PERRY: SE of New Bloomfield on Dix Hill Road, *Cusick 27829* (Sep 1988), road bank. *Tussilago farfara*—CUMBERLAND: near Hunters Run at edge of Michaux State Forest, *Isaac & Isaac 3338* (Mar 1991), roadside gravel.

BETULACEAE: *Alnus glutinosa*—SOMERSET: Barronvale, *Cusick & Shelton 29789* (Aug 1991), along Laurel Hill Creek; apparently first report of this taxon from western PA.

BRASSICACEAE: *Alliaria petiolata*—LAWRENCE: ca 0.25 mi SE of New Bedford, *Isaac & Isaac 3093* (May 1990), along edge of building. *Brassica rapa*—CUMBERLAND: 8 km S of Carlisle, *Zanol 51* (Jul 1990). *Cardamine hirsuta*—ARMSTRONG: 3 mi SSW of Shay, *Thompson & Macdonald 3633* (Apr 1987), along road. *Cardamine impatiens*—CENTRE: SW of Bellefonte, *Cusick 28407* (Jul 1989), along Spring Creek Road; CLARION: just SE of East Brady, *Reznicek & Romme 8129* (May 1988), disturbed open hardwoods, scarce (specimen in herbarium of University of Michigan); LAWRENCE: Wampum, *Isaac & Isaac 3352* (Mar 1991), along railroad tracks. *Thlaspi arvense*—FULTON: 1 mi W of Harrisonville, *Thompson & York 6437* (Jun 1989), ditch through open field.

CAPRIFOLIACEAE: *Lonicera maackii*—WESTMORELAND: SE of New Stanton on PA Turnpike, *Cusick 29073* (Jul 1990), weedy thickets. *Lonicera morrowi*—LAWRENCE: Rose Point, *Isaac & Isaac 3410* (May 1991).

CARYOPHYLLACEAE: *Cerastium nutans*—CAMERON: 7 mi NW of Driftwood, *Buker s.n.* (May 1966), rocky outcrop; previously identified as *C. viscosum*. *Cerastium semidecandrum*—ERIE: Presque Isle State Park, *Grisez 964* (May 1986), edge of beach and woods in sand; first record from western PA, previously reported in the area of Philadelphia and Reading (R. Rabeler pers. comm.). *Scleranthus annuus*—HUNTINGDON: PA Furnace Road at summit of Tussey Mountain, *Cusick 28422* (Jul 1989), road berm; 6 km S of Huntingdon, *Thompson & Rawlins 8352* (May 1991), gravel parking area. *Silene noctiflora*—CUMBERLAND: 8 km S of Carlisle, *Zanol 57* (Jul 1990).

CELASTRACEAE: *Celastrus orbiculata*—BEDFORD: S of Breezewood on I-70, *Cusick 28559* (Sep 1989); CUMBERLAND: NE of Carlisle Springs on PA 34, *Cusick 27813* (Sep 1988); FAYETTE: NW of Perryopolis on PA 51, *Cusick & Shelton 27886* (Oct 1988); FULTON: S of Crystal Springs on I-70, *Cusick 28558* (Sep 1989); SOMERSET: near entrance to Kooser State Park, *Cusick & Shelton 29791* (Aug 1991), edge of woods; WASHINGTON: E of Bentleyville on PA Turnpike, *Cusick 28432* (Jul 1989); WESTMORELAND: NE of Belle Vernon on PA Turnpike, *Cusick 28433* (Jul 1989); widely planted, it has escaped and spread, often overwhelming natural vegetation (Dreyer et al. 1987).

CHENOPODIACEAE: *Atriplex patula*—PERRY: Juniata River S of Millerstown, *Cusick 27825* (Sep 1988), fishing access site. *Chenopodium glaucum*—BEDFORD: NE of Kegg on PA Turnpike, *Cusick 28435* (Jul 1989), road berm; ERIE: junction of US 20 and PA 18, W of Girard, *Cusick 29152* (Aug 1990). *Kochia scoparia* var. *scoparia*—CUMBERLAND: NE of Newburg on PA Turnpike, *Cusick 27854* (Sep 1988), road berm.

CONVOLVULACEAE: *Jacquemontia tamnifolia*—ERIE: Car Works Yard, *Miller s.n.* (Sep 1914); from Miller Herbarium, only western PA record.

CRASSULACEAE: *Sedum sarmentosum*—WASHINGTON: 4 mi W of New Eagle, *Thompson 3707* (Jun 1987), naturalized near small trash dump.

CYPERACEAE: *Carex albicans* var. *emmonsii* (= *C. emmonsii*)—TIOGA: 1.5 mi S of US 6 on road to Colton State Park, *Rettig 1330* (Jun 1985); WARREN: ca 5 mi E of Warren, *Rettig 1343* (Jun 1985), slope above road.

Carex bushii—LAWRENCE: Rose Point, *Isaac & Isaac 3433* (May 1991), dry open field. *Carex bromoides*—MERCER: Mercer, Brandy Springs Park, *Isaac 3467* (Jun 1991), wet hummock; NW edge of Grove City, Tamarack Swamp, *Isaac 3485* (Jun 1991), swampy woods. *Carex lacustris*—LAWRENCE: Rose Point, *Isaac & Isaac 3416* (May 1991). *Carex lucorum*—McKEAN: ca 10 mi W of Bradford, *Rettig 1352* (Jun 1985), along trail. *Carex pensylvanica*—McKEAN: ca 10 mi W of Bradford, *Rettig 1351, 1353* (Jun 1985), along trail. *Carex seorsa*—LAWRENCE: 2 mi NW of Harlansburg, *Isaac 3505* (Jun 1991), pastured swamp on peat mat. *Carex tenera*—ERIE: Presque Isle State Park, *Bissell 1985:101* (May 1985), local on moist flats. *Carex willdenowii*—HUNTINGDON: Rothrock State Forest, 1.6 mi from Whipple Dam State Park, *Rettig 1315* (Jun 1985), dry slope near top of mountain; WARREN: ca 5 mi E of Warren, *Rettig 1344* (Jun 1985), slope above road. *Scirpus atrocinctus*—PERRY: New Bloomfield, *Gress s.n.* (Jul 1920); originally identified as *S. cyperinus*, recently redetermined as *S. atrocinctus* by A. E. Schuyler. *Scirpus atrovirens*—MERCER: Mercer, Brandy Springs Park, *Isaac 3461* (Jun 1991), swale below pond. *Scirpus hattorianus*—CENTRE: N of Farmers Mills on Penns Cave Road, *Cusick 29072* (Jul 1990), moist field.

DIPSACACEAE: *Dipsacus laciniatus*—WASHINGTON: E of Alexander on US 40, *Cusick 28431* (Jul 1989). This is the first record of this European species from western PA.

DRYOPTERIDACEAE: *Dryopteris goldiana*—MERCER: ca 0.1 mi S of Hope Mills, *Isaac 3669* (Sep 1991), along old railroad grade.

ELAEAGNACEAE: *Elaeagnus umbellata*—BUTLER: Lake Arthur, *Thompson 5086* (May 1988); GREENE: 2 km SW of Garards Fort, *Thompson & Rawlins 8321*, (May 1991); WESTMORELAND: Powdermill Nature Reserve, *Utech 91-51* (May 1991), dry rocky slope; specimen from Butler County cited in Thompson et al. (1989) as *E. angustifolia* is an incorrect determination, there are apparently no specimens from Butler County.

FABACEAE: *Lathyrus latifolius*—MERCER: 0.2 mi N of Hope Mills, *Isaac 3668* (Sep 1991), along old railroad grade. *Lespedeza cuneata*—WESTMORELAND: Waltz Mill Station, *Utech 91-1669* (Sep 1991), open sandy area. *Lespedeza nuttallii*—HUNTINGDON: N of Pogue, *Cusick 27844* (Sep 1988), S-facing shale banks along Aughwick Creek. *Lotus corniculatus*—ERIE: junction of US 20 and PA 18, W of Girard, *Cusick 29154* (Aug 1990).

GENTIANACEAE: *Gentianopsis procera*—ERIE: lake shore west, *Miller s.n.* (Oct 1900), clay cliffs; ranges from western New York and southern Ontario to the upper midwestern states (Mason and Iltis, 1965), Miller's collection apparently the only specimen from PA.

HYDROCHARITACEAE: *Elodea canadensis*—ALLEGHENY: NW end of North Park Lake, *Isaac et al. 3509* (Jul 1991), in shallow water.

JUNCACEAE: *Juncus articulatus*—WESTMORELAND: SE of New Stanton on PA Turnpike, *Cusick 29074* (Jul 1990), wet ditch. *Juncus bufonius*—HUNTINGDON: junction of US 22 and PA 45 at Water Street, *Cusick 29082* (Jul 1990). *Juncus dudleyi*—FRANKLIN: Blue Ridge Summit, *Cusick 28615* (Sep 1989), wet field. *Juncus gerardii*—SOMERSET: NE of Somerset on PA Turnpike, *Cusick & Shelton 28942* (Jun 1990), moist, weedy ground; first report from western PA, Stuckey (1980) describes spread westward from east coast through Great Lakes region, tolerance of salt allows it to flourish in man-made saline habitat such as road berms. *Juncus tenuis*—SUSQUEHANNA: Ararat, *Thompson & Macdonald 3377* (Jun 1986), along old railroad bed; previously reported from all counties in PA except Susquehanna (Wherry et al. 1979).

LYCOPODIACEAE: *Lycopodium clavatum*—CUMBERLAND: near Hunters Run at edge of Michaux State Forest, *Isaac & Isaac 3337* (Mar 1991), along roadside bank. *Lycopodium tristachyum*—CUMBERLAND: near Hunters Run at edge of Michaux State Forest, *Isaac & Isaac 3336* (Mar 1991), along roadside bank.

LYTHRACEAE: *Lythrum salicaria*—JUNIATA: Thompsontown, *Cusick 27823A* (Sep 1988), along Delaware Creek.

MORACEAE: *Humulus lupulus*—MERCER: ca 1 mi N of Hope Mills, *Isaac 3663* (Sep 1991), along old railroad grade.

NYSSACEAE: *Nyssa sylvatica*—LAWRENCE: ca 0.5 mi SE of New Bedford, *Isaac & Isaac 3446* (May 1991), field.

OLEACEAE: *Chionanthus virginicus*—ALLEGHENY: 0.5 mi N of Homestead, *Isaac 3643* (Aug 1991), on bluff.

ORCHIDACEAE: *Spiranthes casei*—LYCOMING: Cedar Run Bog, *Gress et al. s.n.* (Sep 1920). McKEAN: S of Cyclone, *Jennings s.n.* (Sep 1937); POTTER: W of Mills, *Graham s.n.* (Sep 1926); specimens originally identified as *Spiranthes cernua* were redetermined by Paul Catling, co-author of *S. casei*, other than Catling's unpublished thesis (pers. comm.) not reported for PA.

ONAGRACEAE: *Ludwigia peploides*—ALLEGHENY: NE end of North Park Lake, *Isaac et al. 3510* (Jul 1991), in shallow water.

OXALIDACEAE: *Oxalis corniculata*—SOMERSET: PA Turnpike at Somerset, *Cusick 27856* (Sep 1988), motel area.

POACEAE: *Calamagrostis porteri*—JUNIATA: Tuscarora Mountain, NW of Ickesburg, *Cusick 27824* (Sep

1988); PERRY: Tuscarora State Forest, SE of East Waterford, *Cusick 27801* (Sep 1988). *Digitaria sanguinalis*—LAWRENCE: ca 0.25 mi SE of New Bedford, *Isaac & Isaac 3298* (Sep 1990), garden weed. *Diplachne acuminata* (= *Leptochloa acuminata*)—CUMBERLAND: NE of Carlisle on PA Turnpike, *Cusick 27798* (Sep 1988), road berm; FRANKLIN: SE of Willow Hill on PA Turnpike, *Cusick 27800* (Sep 1988), road berm; first collected in PA in 1984 (Cusick 1988), has spread rapidly along salted roadways and now known from eight counties in western PA. *Hordeum jubatum*—WESTMORELAND: ca 2 mi SSE of Latrobe, *Utech 91-704*, (Jul 1991), open sandy roadside meadow. *Lolium perenne*—LAWRENCE: just E of Neshannock Falls, *Isaac 3735* (Sep 1991), roadside. *Microstegium vimineum* (= *Eulalia viminea*)—CUMBERLAND: Colonel Denning State Park, SW of Doubling Gap, *Cusick 27818* (Sep 1988), picnic area; HUNTINGDON: N of Pogue, *Cusick 27843* (Sep 1988), along Aughwick Creek; JUNIATA: Thompsontown, *Cusick 27822A* (Sep 1988), along Delaware Creek; PERRY: Tuscarora State Forest, S of East Waterford, *Cusick 27807* (Sep 1988), along streams. *Panicum agrostoides*—PERRY: S of Millertown, *Cusick 27824A* (Sep 1988), along Juniata River. *Panicum dichotomiflorum*—LAWRENCE: ca 0.25 mi SE of New Bedford, *Isaac & Isaac 3301* (Sep 1990), garden weed. *Phragmites australis*—WESTMORELAND: ca 5 mi ENE of Waterford, *Utech 91-1989* (Sep 1991), wet areas along roadside. *Puccinellia distans*—CENTRE: Buffalo Run, *Cusick 28411* (Jul 1989), weedy ground; CLARION: W of Wentlings Corners on I-80, *Cusick 28396* (Jul 1989), road berm; CLEARFIELD: NE of Clearfield on I-80, *Cusick 28395* (Jul 1989), road berm; ERIE: junction of US 20 and PA 18, W of Girard, *Cusick 29151* (Aug 1990); MERCER: junction of I-79 and I-80, SE of Mercer, *Cusick 28398* (Jul 1989); spread along salted roadways throughout western PA since mid-1980's (Cusick 1988). *Setaria faberi*—ALLEGHENY: 4 km N of Tarentum, *Zanol 181* (Jul 1990); BEAVER: between Koppel and Homewood, *Utech 87-803* (Aug 1987), open wet seepage slope; INDIANA: ca 4 mi N of Blairsville, *Utech 90-1226* (Aug 1990), fields and meadows; SOMERSET: 2.25 mi NNE of Thomas Mills, *Ross s.n.*, dry roadside; WESTMORELAND: ca 3 mi SW of Rector, *Utech 81-346a* (Jul 1981), ruderal meadow. *Setaria glauca*—LAWRENCE: just E of Neshannock Falls, *Isaac 3713* (Sep 1991), along creek. *Torreyochloa pallida* (= *Glyceria pallida*)—CRAWFORD: S of Pennline on Phelps Road, *Cusick 29025* (Jul 1990), along Pymatuning Lake.

POLYGONACEAE: *Polygonum aviculare*—LAWRENCE: just E of Neshannock Falls, *Isaac 3710* (Sep 1991), along creek. *Polygonum caespitosum*—FAYETTE: between Indian Head and Nebo, *Utech 91-1338* (Aug 1991), sandy soil; FOREST: ca 1 mi S of Tionesta, *Isaac 3796* (Oct 1991), along highway; LAWRENCE: just E of Neshannock Falls, *Isaac 3718* (Sep 1991), along creek. SOMERSET: Forbes State Forest along Jones Mill Run, *Utech 91-1319* (Aug 1991), sandy soil. *Polygonum perfoliatum*—ADAMS: NW of Marshall on Cold Springs Road, *Cusick 28611* (Sep 1989), weedy thicket; population reported here very local, has the potential to become major weed species in state (Cusick 1987). *Rumex obtusifolius*—FAYETTE: between Indian Head and Nebo, *Utech 91-1343* (Aug 1991), wet sandy soil; now collected from all PA counties. *Rumex orbiculatus*—ERIE: Presque Isle, *Jennings s.n.* (Aug 1905); previously identified as *R. verticillatus*, recently redetermined as *R. orbiculatus* by James Bissell.

PRIMULACEAE: *Lysimachia thyrsiflora*—LAWRENCE: Rose Point, *Isaac & Isaac 3442* (May 1991), swamp.

SAXIFRAGACEAE: *Ribes glandulosum*—FOREST: 6 km NNW of Pigeon, *Thompson & Rawlins 8309* (Apr 1991), on large boulders.

RANUNCULACEAE: *Ranunculus bulbosus*—LAWRENCE: near Neshannock Falls, *Isaac & Isaac 3398* (May 1991), edge of wet deciduous woods. *Ranunculus repens*—LAWRENCE: Rose Point, *Isaac & Isaac 3366* (Apr 1991), swampy deciduous woods along gravel road.

RHAMNACEAE: *Rhamnus alnifolia*—MERCER: 1.3 km W of Sandy Lake, *Bier s.n.* (Sep 1989), edge of wooded swamp and shrub swamp border.

ROSACEAE: *Fragaria virginiana*—LAWRENCE: Rose Point, *Isaac & Isaac 3371* (Apr 1991), along gravel road; now collected in all counties in PA. *Rhodotypos scandens*—ALLEGHENY: Pittsburgh, *Thompson 630* (May 1983), growing along banks of ravine. *Rosa multiflora*—LAWRENCE: ca 0.5 mi SE of New Bedford, *Isaac & Isaac 3451* (May 1991), overgrown field.

RUBIACEAE: *Galium concinnum*—WESTMORELAND: ca 2 mi SSE of Latrobe, *Utech 91-690* (Jul 1991), sandy roadside meadows.

SALICACEAE: *Populus × gileadensis*—CRAWFORD: NW of Shermanville on US 6, *Cusick 29024* (Jul 1990), moist ground.

SCROPHULARIACEAE: *Chaenorrhinum minus*—CUMBERLAND: Blue Mountain, SW of Doubling Gap, *Cusick 27817* (Sep 1988), road berm. *Lindernia dubia*—FULTON: Sideling Hill Creek, SE of Barnes Gap, *Cusick 27704* (Aug 1988). *Paulownia tomentosa*—ALLEGHENY: Pittsburgh, near Highland Park, *Zanol 371* (Sep 1990), persisting along roadside.

SPARGANIACEAE: *Sparganium eurycarpum*—SUSQUEHANNA: 0.5 mi E of I-81 on PA 171, *Thompson & Macdonald 3383* (Jun 1986), roadside pond.

VERBENACEAE: *Phyla lanceolata* (= *Lippia lanceolata*)—MERCER: Shenango Reservoir, *Lochner s.n.* (Sep

1990), on south shore.

VITACEAE: *Vitis cinerea* var. *baileyana* (= *V. baileyana*)—ALLEGHENY: 1 mi W of Glenshaw, *Jennings s.n.* (Jun 1919), along west branch of Little Pine Creek; FAYETTE: near South Connellsville, *Graham s.n.* (May 1934), above Youghiogheny River; FULTON: 0.5 mi N of Maryland border, *Buker s.n.* (May 1963), along Big Tonoloway Creek; GREENE: 2 mi S of Ryerson, *Henry & Beer s.n.* (Aug 1951); ca 5 mi above mouth of Dunkard Creek, *Graham s.n.* (Jun 1934); WASHINGTON: Riverview, *Gress s.n.* (Jun 1919); WESTMORELAND: ca 3 mi above mouth of Jacob's Creek, *Graham s.n.* (Jun 1934); previously not known from PA, these specimens originally identified as several different species were redetermined by Michael Moore.

ACKNOWLEDGMENTS

We thank Charles Bier, James Bissell, Bonnie and Joe Isaac, Fred Lochner, Jeff Rettig, Fred Utech, Walter Zanol, and the Erie Historical Museum and Planetarium for depositing specimens at CM and making these records available. We also thank James Bissell, Paul Catling, and Michael Moore for sharing unpublished data.

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Bartonia No. 58: 75-77, 1994

Magnolia tripetala in Pennsylvania

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Magnolia tripetala L., Umbrella tree, is a sub-canopy tree of low elevation, deciduous forests of the southern Appalachians from Georgia and Arkanasa north to Pennsylvania, West Virginia, Ohio, Kentucky and Missouri (Little 1977). In Pennsylvania it is found in the wooded ravines along the lower reaches of the Susquehanna River where it occurs with other components of a diverse, mixed deciduous forest dominated by Tuliptree (*Liriodendron tulipifera*), another member of the family Magnoliaceae. The species is also found at scattered sites in central and southwestern counties (Wherry et al. 1979) within the mixed mesophytic forest zone described by Braun (1950).

Magnolia tripetala is also found in several counties of southeastern Pennsylvania. However, the fact that it is not mentioned in the early floras of Philadelphia, Bucks or Chester Counties is curious (Barton 1818, Darlington 1837, Porter 1903, Small 1913, Benner 1933, Stone 1945). Keller and Brown (1906) report the species as cultivated at Bartram's Garden and the Zoological Garden in Philadelphia as well as occurring naturally in woods along the Susquehanna River in Lancaster County. A tree with leaves 18 to 24 inches long is not easily overlooked, and surely would have been noticed by the early botanists had it been a component of the forests in the Philadelphia area. One has to question whether *Magnolia tripetala* is a recent arrival in southeastern Pennsylvania.

An examination of the herbarium specimens at the Academy of Natural Sciences is revealing. The earliest specimen of *Magnolia tripetala* from southeastern PA, other than the one planted at the Westtown School in Chester County in 1906, was collected in 1921 in Montgomery County. A note on the specimen says "single tree, woods, Militia Hill." There are hundreds of individual trees of all ages at that site today which is part of Fort Washington State Park.

In 1922 *Magnolia tripetala* was noted as being "abundantly naturalized" in woods along Tacony Creek in Montgomery County adjacent to northeast Philadelphia and by 1924 it was reported from the Wissahickon Ravine in the city. Its spread in the Wissahickon is charted by specimens collected in 1937, 1949 and 1964 when it was reported as "well established." Today the species is abundant on slopes along the Wissahickon near Rittenhouse Village.

The earliest record from Bucks County (north of Philadelphia) is from 1937, the specimen carries the note "established in thicket in the vicinity of Newportville." By 1970 it had moved north to the area around Bristol, and by 1989 additional populations had been located even further north. At one site near Emilie, several hundred plants of all ages were scattered throughout a woodland dominated by *Liriodendron tulipifera*. In addition the species had become very abundant in the Delhaas Woods near Bristol, where an estimated 500 or more trees, comprising all age classes, dominate the sub-canopy in several acres of low, moist, Coastal Plain woods.

In Delaware County, in the western suburbs of Philadelphia, *Magnolia tripetala* as collected three-quarters of a mile west of Haverford in 1939 and noted as "an escape now abundant in thin woods." By 1946 it was reported as "naturalized in woods near the Tyler Arboretum" 2 miles northwest of Media.

Other than the record of a planted specimen at the Westtown School in 1906 there were no collections of *Magnolia tripetala* from Chester County until very recently. However, in 1989 it was collected near Oxford where several hundred plants were noted in a remnant woodland along Route One. Another smaller population was noted in woodlands adjacent to the Nottingham Serpentine Barrens in the same year (Rhoads and Klein).

Magnolia tripetala is classified as rare by PA DER (Pennsylvania Department of Environmental Resources 1987) but is not considered globally endangered because of its more frequent occurrence outside the state (Pennsylvania Natural Diversity Inventory). It is apparent from the herbarium records cited above and the absence of any reference to native occurrence of the species in the published floras of southeastern Pennsylvania (even as late as 1945), that *Magnolia tripetala* is a fairly recent arrival in woodlands in this part of the state.

In addition to the 1906 reference by Keller and Brown to *M. tripetala* at Bartram's Garden and the Zoo, it is known that the species was grown at the nursery and botanical garden established by Humphrey Marshall in Chester County, PA 1773–1813 (Gutowski 1988). By the mid to late 1800s prominent American landscape architects such as A. J. Downing and Samuel Parsons were extolling the virtues of the tree for use in estate gardens (Downing 1852, Scott 1886, Parsons 1895) and Hedrick (1988) mentions that *M. tripetala* was also used for understock for more tender species of magnolia.

Whether its sudden appearance in the Philadelphia area in the 1920s represents spread from cultivated sources or natural dispersal events is debatable. However, the spread of the species in the counties around the city, as indicated from the herbarium records, seems to radiate from Philadelphia, not from the known native occurrences in Lancaster Co. What is clear is that *Magnolia tripetala* is actively expanding its range in the state, and developing sizeable populations at a number of woodland sites in the Piedmont and Coastal Plain provinces.

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Bartonia No. 58: 79-96, 1994

Additions, Range Extensions, Reinstatements, and Relocations in the New Jersey Flora

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This is the fourth in a continuing series of papers for Bartonia reporting on recent discoveries of rare native New Jersey plant species. In this paper four species (*Atriplex subspicata, Cardamine maxima, Carex formosa, Carex joorii*) are reported as apparent additions to New Jersey's flora. All but one (*Cardamine maxima*) of these species are range extensions, as is also *Carex louisianica.* The remaining taxa are all reinstatements of historical or extirpated species. The majority of these reinstatements are of taxa which apparently have not been collected in New Jersey for more than 50 years, or in a few cases, not collected since the last century. While most were discovered at new locations, several of these taxa were relocated at the same location from which they had been collected over 25, 50, or 70 years prior. Such relocations underscore the longevity that rare plant species often demonstrate, and such lapses of time frequently reflect only a lack of active fieldwork, and are not, therefore, reliable as evidence that a species has been truly extirpated from New Jersey.

Nomenclature, unless noted otherwise, follows Kartesz and Kartesz (1980) or Gleason and Cronquist (1991). Species are arranged alphabetically within phylogenetical sequence according to Cronquist in Gleason and Cronquist (1991). Duplicate specimens of all taxa discussed will be placed in CHRB, with some additional duplicates deposited at PH.

Quercus imbricaria

A small grove of about 20 twenty trees of *Quercus imbricaria* was located on 10 September 1989 on the wooded slope of a greensand marl (glauconite) ravine along Mantua Creek at Wenonah, Gloucester County. This is a relocation of Robert Hirst's 1962 station (along railroad, south edge of Wenonah, 25 Aug 1962, *B. Hirst s. n.*, PH), which in turn, apparently is a relocation of a 1904 collection from Wenonah (Wenonah, 25 September 1904, *G. T. Hastings s. n.* NY). It was growing in association with *Pinus virginiana, Quercus alba, Q. montana, Liriodendron tulipifera, Carya* sp., *Plantanus occidentalis, Acer rubrum, Juglans nigra, Cornus florida,* and *Sassafras albidum.* Some of the *Q. imbricaria* trees were estimated to be 50 feet high. There is no strong evidence suggesting that these trees were planted or derived from cultivated trees, although the clearing of some woodland to create a ballfield, has now left a few trees standing in a mowed lawn.

Quercus imbricaria is much more common west of the Appalachians, and reaches its greatest abundance in the Central Lowland Province (Hunt 1990). The distribution of *Q. imbricaria* in New Jersey has been reported as scattered throughout most of the Coastal Plain counties, from Mercer south to Cape May (Fairbrothers and Hough 1973; Snyder and Vivian 1981; Hough 1983), but this is largely erroneous and is based primarily on misidentified specimens at CHRB and PH. Some of the counties included in Hough (1983) are based on specimens collected from cultivated trees. Most of the remaining specimens are apparently hybrids involving *Q. phellos* and other species. New Jersey's most infamous imposter *imbricaria* are the trees along Highs Beach Road on the Cape May bayshore. These problematic trees have been the source of debate for more than 30 years, with opinions and annotations running from hybrid taxa to *Q. laurifolia*, and most recently, *Q. imbricaria.* These specimens (CHRB) have now been identified as *Q. phellos* × *Q. marilandica* (Hunt 1990). Hunt (pers. comm.) has likewise disposed of all of the New Jersey specimens filed as *Q. imbricaria* at PH as misidentifications, with the exception of the Hirst specimen. Apparently Wenonah is the only native site documented in New Jersey.

The Wenonah trees had a very densely tomentose, almost velvety, surface on the undersides of the leaves. This character is absent from the CHRB and PH hybrid specimens, as well as from other material I have collected elsewhere on the Coastal Plain and incorrectly identified as *Q. imbricaria.* The leaves of all the latter material are essentially glabrous underneath, with the exception of a few scattered hairs, or tufts of hairs, in the vein-axils. The only other *Quercus* in New Jersey that might possibly be confused with *Q. imbricaria,* would be exceptionally large leaved *Q. phellos*, but the leaves of this species also lacks the permanently tomentose undersides.

Atriplex subspicata

Plants of a puzzling *Atriplex* were collected on 21 October 1988 in a salt marsh along Wigwam Creek, east of Port Republic, Atlantic County. Unlike the deep green and strongly hastate leaved *A. prostrata*, these plants were a peculiar, almost silvery, lighter green, and the upper leaves (most of the lower leaves had dropped) were lanceolate without the slightest hint of basal lobing. With the standard northeastern manuals (Fernald 1950; Gleason 1952; Gleason and Cronquist 1963) specimens keyed to *Atriplex patula* var. *littoralis*, but they did not compare well to other specimens identified by Taschereau as *A. littoralis* at NY. Using Taschereau's (1972) treatment, the mysterious *Atriplex* keyed to *A. subspicata.* This species differs from other nonhastate, narrow leaved *Atriplex* species in its seeds, which are wider than high, and its radicle, which is median. *Atriplex glabriuscula* is the only other species of *Atriplex* occurring in northeastern North America that has a median radicle, but it also has an inflorescence that is leafy bracted throughout (*A. subspicata*'s inflorescence is leafy bracted only at the base) and it is not known to occur in New Jersey.

Atriplex subspicata was described in 1818 by Nuttall and occurs in coastal areas of eastern Canada south to North Carolina, and in saline habitats in western Canada and in the western and central United States (Taschereau 1972; Bassett, et al. 1983). Most eastern collections of *A. subspicata* have been identified as varieties of *A. patula*, primarily because all of our eastern manuals follow Gray's 1868 treatment of the genus (Taschereau 1972).

In 1990 I returned to the Atlantic County site to collect additional specimens, but after careful searching, no plants were found. The site is located within the Forsythe (formerly Brigantine) National Wildlife Refuge in which some recent wildlife enhancement activities (digging ponds for waterfowl) have taken place. I don't think this is the cause of the seeming disappearance of *A. subspicata.* Being an annual species growing in a tidal habitat, it's likely that seeds do not always fall and germinate in the same spot year after year.

Potential unexplored habitat for this species is extensive. It grew in a salt marsh dominated by a thick carpet of *Spartina patens* with scattered areas of open muddy patches with the occasional *Limonium carolinianum* and the usual assortment of *Salicornia* and *Suaeda*. This type of habitat is abundant throughout coastal New Jersey.

Chenopodium berlandieri var. macrocalycium

Chenopodium berlandieri var. *macrocalycium* was described as a species by Aellen in 1929 (Wahl 1954). It is treated as a variety of *C. berlandieri* by Cronquist (Gleason and Cronquist 1991). In gross morphology var. *macrocalycium* resembles *C. album*, and *C. berlandieri* and its vars. *bushianum* and *zschackei*. *Chenopodium berlandieri* var. *macrocalycium* is easily distinguished from the *C. album* complex by its obviously reticulated pericarp. *Chenopodium berlandieri* var. *bushianum* and var. *zschackei* both have reticulated pericarps but the latter variety has a light yellowish area at the base of the style and the leaves are white-mealy (unlike either vars. *bushianum* or *macrocalycium*). It is also mostly western in distribution, and is not known to occur in New Jersey (Wahl 1954; Gleason and Cronquist 1991). The var. *bushianum* has larger seeds then does var. *macrocalycium* (1.5–2.3 vs. 1.3–1.7) its inflorescence typically droops, and it mostly occurs as a weed in cultivated fields (*Koster D11-20-1*, PH) and waste places (*Brown s. n.*, PH).

Chenopodium berlandieri var. *macrocalycium* is primarily coastal in distribution occurring from Newfoundland south to North Carolina and also inland in the upper Mississippi drainage and the Great Lakes (Wahl 1954; Gleason and Cronquist 1991). The majority of New Jersey collections were made from sea beaches in Monmouth, Ocean, Atlantic, and Cape May counties, and from the Delaware River Bayshore in Cape May County (see Wahl 1954 for specimen citations). The most recent specimen contained in our local herbaria (CHRB, NY, PH) was collected 16 October 1937 (*Ludwig 643* PH). Apparently the only recent records for *C. berlandieri* var. *macrocalycium* are those I collected at Sandy Hook, Monmouth County on 21 September 1986 and from the Tuckerton Marshes, Ocean County, on 14 September 1986 and 21 October 1988. At both locations the plants were growing in damp sand at the upper limits of a bayside salt marsh. What led me to these locations were some recent unvouched reports of *C. rubrum*, but as I far as I can tell, *C. rubrum* is not present at either site. The superficial resemblance of the two taxa may account for some of the unsubstantiated reports of *C. rubrum* in New Jersey.

Chenopodium rubrum

Chenopodium rubrum has been reported as a native New Jersey plant in both the early literature (Knieskern 1856; Britton 1889; Britton and Brown 1913; Stone 1912; Taylor 1915) and in recent manuals (Fernald 1950; Gleason 1952; Gleason and Cronquist 1963) and state checklists (Anderson 1989; Hough 1983; Schmid 1990). I have been unable to locate specimens at BK, CHRB, CU, GH, NY, or PH that substantiate these reports. On the contrary, the specimens that I have seen at these institutions all seem to support a nonnative status: CAMDEN CO.: Ballast, Camden, 23 Sep 1877, *C. F. Parker s. n.*, CHRB; Ballast, Camden, 15 Aug 1879, *C. A. Boice s. n.*, PH; Ballast, Camden, 30 Aug 1879, *C. F. Parker, s. n.*, GH; Kaighn's Point, 1898, *A. Jahn, s. n.*, PH; On ballast, Kaighn's Point, [not dated] *I. Burk, s. n.*, PH. HUDSON CO.: Hoboken, [undated and without collector's name] NY.

Stone (1912) apparently also had difficulty in verifying these early reports of *C. rubrum* as evidenced by his statement, "It is true that it has been mentioned in all the lists, but apparently without any definite knowledge of its occurrence, and I have been unable to find any specimens in the herbaria that I have examined except those collected by Mr. Bayard Long on Barrel Island, near Tuckerton, September 11, 1908." I have been unable to locate Long's specimens cited by Stone. Stone missed the Burk and Parker Camden specimens cited above even though he acknowledged examining their herbaria (Stone 1912).

More recently *C. rubrum* was reported, but not collected, from Secaucus, South Amboy, Sandy Hook, Island Beach, Barnegat, Tuckerton Marsh, and Moore's Beach by Vincent

Abraitys (1957-1983) and from Seven Bridges, near Tuckerton by Gilbert Cavileer (pers. comm.). This last location is about four miles southwest of where Long reportedly collected it and may be also the same as Abraitys' Tuckerton Marsh record. I have searched this site, as well as Abraitys' Sandy Hook and Island Beach locations (plus many other seemingly suitable areas along the coast), but without success. It is possible that at least some of these reports may be based on misidentified *C. berlandieri* var. *macrocalycium* (see discussion above). In 1978, Joe Arsenault collected *C. rubrum* northeast of Smithville (about 6 miles east of where Cavileer reported it) and deposited a specimen in the herbarium of Rutgers' Camden campus. No plants were located at this site in 1988 when Joe, Ted Gordon, and I made a careful search. Joe also told me about another specimen of *C. rubrum* that had been collected along the Tuckahoe River in Atlantic County on 23 September 1982 by Leo Snead, Jr. I examined this specimen, now at CHRB, in late 1989 and got very precise directions to the location. It is on the north bank of the Tuckahoe River, Atlantic County, approximately 2.5 miles northeast of Middletown. On 12 October 1990 I found a patch of 28 plants here in a dense stand of *Spartina cynosuroides*, growing with *Limonium carolinianum*, *Kosteletzkya virginica*, *Teucrium canadense*, and *Pluchea odorata*. The site is remote and accessible only by boat, and introduction by any but natural means, seems unlikely. In 1991, Stephen Field found a population along Great Cedar Swamp Creek, Cape May County, not too far from the above site. Thus doubt and rumor can be put to rest—*C. rubrum* does occur in New Jersey as a native species.

Lechea tenuifolia

The only documented location for *Lechea tenuifolia* in New Jersey is Ringwood Junction, Passaic County, collected by K. K. Mackenzie in 1916 and 1917 (Dry sunny bank, local, 7 Jul 1916, *7145*, NY, PH; Dry fields, Ringwood Junction, 20 May 1917, *7608*, CHRB, NY, PH). By the late 1920s, Ringwood Junction existed no more, having been flooded to create Wanaque Reservoir. Curious as to whether some *L. tenuifolia* might have survived at higher elevations adjacent to the reservoir, I made a search on 18 September 1990 and located a population of 58 plants (Snyder 1993). They were in a clearing on a rock ledge in very dry soil. Associated species included *Aster liniariifolius*, *Solidago bicolor*, *Hieracium paniculatum*, *H. venosum*, *Lysimachia quadriflora*, *Potentilla canadensis*, *Quercus alba*, *Q. rubra*, *Fraxinus americana*, and *Acer saccharum*.

The habitat seemed very ordinary and similar to hundreds of other places in northern New Jersey. If habitat for this species is so abundant, why is *Lechea tenuifolia* so rare in New Jersey? Although it may be undercollected in the state, I suspect that this species will remain extremely rare in New Jersey. Although much more abundant in the western and southern portions of its range, *L. tenuifolia* can hardly be considered peripheral in New Jersey, ranging as it does from Maine, south to South Carolina, and interuptedly west to Minnesota and Texas (Fernald 1950, Gleason and Cronquist 1991). The species apparently is of spotty and local distribution throughout the Northeast, and eight states (Maine, New Hampshire, New York State, Ohio, New Jersey, Delaware, Maryland, West Virginia) track it at some level of rarity (The Nature Conservancy's Biological and Conservation Database). Whatever the factors may be that are limiting the distribution of *L. tenuifolia* in the northeast, it seems unlikely that it is a result of a lack of suitable habitat.

Cardamine maxima

Cardamine maxima is a plant of northern affinity, ranging from New Brunswick, south through New England to northern New Jersey, Pennsylvania, West Virginia and Kentucky, and west to Ontario, Michigan, and Wisconsin (modified from Montgomery 1955, Gleason and Cronquist 1991). It is local to rare in most areas of its range with its main distribution in New York State, and southeastern Canada (Montgomery 1955).

In morphological characters it is intermediate between *Cardamine concatenata* and *C. diphylla*, differing primarily in its rhizome, which is alternately enlarged and only slightly constricted along its length. In *C. concatenata* the rhizome is formed of a series of fragile, tuber-like segments, while *C. diphylla*'s rhizome is without any constrictions, maintaining a constant diameter throughout its length. *Cardamine maxima* can be further distinguished from *C. diphylla* by its leaflets which bear along their margins spreading trichomes 0.2-0.3 mm long; those of *C. diphylla* are 0.1 mm and appressed. The number, shape, and position of cauline leaves are variable (Bissell 1903; Montgomery 1955), and are unreliable morphological characters. *Cardamine maxima* frequently has three alternate cauline leaves, but varies between one to four or more (Bissell 1903; Montgomery 1955). *Cardamine diphylla* typically has two alternate or opposite cauline leaves and *C. concatenata* frequently has three opposite to subopposite leaves; but again this is variable, particularly in *C. concatenata* (Fernald 1950; Montgomery 1955).

Its variability, and seemingly intermediate morphological characters, has led some workers to consider *C. maxima* to be of hybrid origin (Montgomery 1955; Voss 1985; Gleason and Cronquist 1991). Wiegand and Eames (Montgomery 1955) suggested that *C. maxima* was a hybrid between *C. concatenata* and *C. diphylla*. Montgomery (1955) has shown that both these taxa and *C. maxima* are sexually sterile and that the chromosome number of *C. maxima* also does not show it to be a direct hybrid between these species. He concluded that *C. maxima* "is a member of the agamic complex that originated before complete sexual sterility was effected in the members of the complex. It may have been derived during some interglacial period of the Pleistocene glaciation" (Montgomery 1955). And although polymorphic, *C. maxima* is no less variable than its sexually sterile near relatives, *C. concatenata* and *C. diphylla*. There would seem then, little taxonomic consistency in treating only one of the taxa in the *concatenata-diphylla-maxima* complex as a hybrid. I prefer to follow Montgomery (1955) and Rollins (in Kartesz and Kartesz 1994, J. Kartesz pers. comm.) and recognize *C. maxima* as a valid species.

The New Jersey record is based on a single station located in a ravine along the Shimmers Brook in Millbrook, Sussex County. In 1985, I collected specimens on 28 April and 4 May that were variable in height, and number and shape of the leaves. On 26 April 1991, I found hundreds of plants in scattered, dense colonies that were interspersed among colonies of *C. diphylla*. Also present, were plants of what I had mistakenly identified as *C. concatenata* during my 1985 surveys. These plants are much smaller than either *C. diphylla* or *C. maxima*. The mostly two, opposite to alternate cauline leaves, are much more divided, with the divisions narrower, and with fewer, but sharper incisions. The foliage is blue-green, unlike the yellow-green foliage of *C. diphylla* and *C. maxima*. Although the root stock of an occasional plant was more obviously constricted than either of these taxa, root stocks of the majority of plants were identical to *C. maxima*. In addition to the nearly perpendicular coarse trichomes along the leaf margins, some of the plants also had few to many similar trichomes on the stems and on one or both surfaces of the leaves. These plants key to what has been described as *Cardamine* (*Dentaria*) *anomala* (Eames 1903; Gleason 1952; Gleason and Cronquist 1991) or *C.* × *anomala* (Fernald 1950; Kartesz and Kartesz 1994). But given the sexual sterility and the polymorphic nature of this complex, I prefer to recognize *C. anomala* as an extreme expression of the *C. maxima*, to which it most closely resembles.

Both *C. maxima* and *C. diphylla* grew either along the banks of a small stream or on the adjacent narrow floodplain. It is a mixed deciduous forest with *Acer saccharum*, *Plantanus occidentalis*, and *Tsuga canadensis* the common canopy species. Associated herbs include *Arisaema triphyllum*, *Symplocarpus foetidus*, *Allium canadense*, *Erythronium americanum*, *Smilacina racemosa*, *Uvularia perfoliata*, and the ubiquitous *Alliaria petiolata*. *Cardamine maxima* (including "*C. anomala*") was both in flower and in bud, while *C. diphylla* had more buds than open flowers.

Pyrola chlorantha

Pyrola chlorantha is circumboreal in distribution, occurring in the northeastern United States south to Maryland and West Virginia (Gleason and Cronquist 1991). In New Jersey in has been collected predominately from sites on the Coastal Plain. Its distribution on the Coastal Plain, while scattered (Monmouth, Atlantic, Burlington, Camden, Gloucester, and Cumberland counties), is more concentrated in the Delaware River drainage, with the majority of collections having been made in Burlington and Camden counties. There are only a few sites for this species that are not Coastal Plain, these being single locations in each of Sussex, Passaic, and Morris counties.

My relocation of *Pyrola chlorantha* just south of the New York state line, on 15 June 1989, apparently remains the only confirmed extant occurrence of this species in New Jersey. In our local herbaria there are least 52 specimens collected from approximately 33 separate locations in nine counties. For more then a decade I searched these historical locations before finding what I presume to be Wherry's 1948 site: Sussex County: Under pines across road from Rockview Hotel, southwest of Duttonville, *s. n.*, PH. Sixteen plants occurred scattered over a few feet of dry ground under *Pinus strobus*. Of these, only three produced flowers. This site, which is located in Montague Township, is the most recent New Jersey collection and it also may be the same as H. H. Rusby and N. L. Britton's 1884 collection from "Montague Township" (CHRB) and Mackenzie's 1910 collection from "pine woods along Delaware River, Montague Township" (NY).

Despite the numerous historical locations for *P. chlorantha*, it apparently never was abundant in the state. Stone (1912) describes it as "everywhere local and not abundant." Still, with so many historical locations for this species in the state, I have to wonder why no new populations have been discovered or why no additional historical sites have been relocated. Part of reason may be a combination of lack of recent fieldwork and the inconspicuous appearance of the species, particularly when not in flower. Another part of the reason is that several historical sites have been destroyed, especially those located in Burlington and Camden counties where expanding cities and sprawling suburbs have covered much of the species former habitat. With the strength of New Jersey's wetland laws, upland habitats are more vulnerable than ever. It may be too, that like some other northern taxa that are disjunct, or at the southern limits of their ranges, deteriorating climatic and habitat conditions and genetic isolation has led to inbreeding depression, and populations simply can no longer maintain themselves. We may be witnessing the continued northward retreat of a species that may be a relict from a time when New Jersey's Coastal Plain was dominated by taiga, tundra, muskegs, and mastodons (Wolfe 1977; Heusser 1979; Pielou 1991).

Cercis canadensis

While popularity of *Cercis canadensis* is great for the nursery trade, from the standpoint of the biogeographer, it presents a difficult question: How do you tell the native populations from those that may have originated from cultivated plants? In states where *Cercis* is a frequent component of the native vegetation, this question is relatively trivial in understanding its overall distribution. But when the species is rare, or at the geographical limit of its range in a particular state, as is *Cercis* in New Jersey, the question becomes critical to the conservation and legal protection of the species.

The species has a broad geographical distribution ranging from southern Connecticut, southeastern New York State, central New Jersey, then south to northern Florida, west through southern Ontario, Michigan, and Wisconsin, and south to Texas and northeastern Mexico (modified from Hopkins 1942; Fernald 1950; Gleason and Cronquist 1991). While there is sufficient documentation that there are at least some native populations of *Cercis* in New Jersey, (Torrey 1819; Britton 1889; Stone 1912, Taylor 1915; Sargent 1922), the reports of the species as being native in Connecticut and New York State have been questioned.[1]

The best evidence that *Cercis* occurs in New Jersey as a native, comes from the Delaware River drainage where it was first collected in 1869 (Camden Co.: Banks of the Delaware below Kaighn's Point, Camden. 5 May 1869, *C. F. Parker s. n.*, CHRB). This location is listed by Britton (1889) as "Camden: In damp woods on the bank of the Delaware, between Camden and Gloucester—Parker." As unlikely as Camden may seem as a site for a native population of *Cercis*, the woods and swamps at Kaighn's Point supported a number of rare New Jersey plant species (Stone 1912). Other sites for *Cercis* along, or near, the Delaware River are Bordentown (A. C. Stokes in Britton 1889, no specimen found), Burlington County; Stockton (1 Aug 1895, *H. L. Fisher s. n.*, PH), Rosemont (G. N. Best in Britton 1889, no specimen found), Hunterdon County; and banks of the Delaware, north of Trenton (A. C. Apgar in Britton (1889) no specimen found), Moore's Station (6 May 1884, *A. C. Apgar s. n.*, CHRB), Titusville (10 May 1901, without collector's name or number, Trenton State Museum), all Mercer County. I believe that all the Mercer County records refer to the same general locality, if not actually the same site. This site, which I relocated 30 April 1989, is on the western slope of Strawberry Hill (locally known as "Kuser Mountain"), 0.5 mile south of Moore's Station, one mile northwest of Titusville, and about eight miles north of Trenton. The habitat is a rich, mixed deciduous woods on a steep, boulder strewn diabase hillside. On subsequent visits made 3 May, 30 August 1989, and 13 August 1990, 11 trees were located scattered from the foot of the slope to its crest. Although no trees were found that produced fruits, numerous young saplings were observed near two of the largest trees. Growing with, or nearby *Cercis* are several other rare New Jersey plant species: *Agastache nepetoides*, *Agrimonia microcarpa*, *Chaerophyllum procumbens*, *Cynoglossum virginianum*, *Jeffersonia diphylla*, *Hybanthus concolor*, *Panax quinquefolius*, *Stachys hispida*, and *Tradescantia ohiensis*. Most of these species are characteristic of rich (often calcareous) woods, and *Cercis* is hardly out of place in this association.

Further evidence that *Cercis* is native in the woods at this site (and probably elsewhere in the Delaware Valley) is that native populations of *Cercis* occur in adjacent Pennsylvania

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[1] The record for Connecticut for *Cercis* as a native species is based on a single clump of trees located within New Haven County Park (Nichols 1923; Reeder 1951). Although this record is accepted as a natural occurrence by Hopkins (1942), Fernald (1950), and Dowhan and Craig (1976), Les Mehrhoff (pers. comm.) remains skeptical, since the collection locality is known to have planted occurrences of some other rare Connecticut taxa. Early editions of Gray's Manual, as well as the eighth edition (Fernald 1950) have included southern New York State within the native range of *Cercis*. Richard Mitchell (pers. comm.) is of the opinion that all records from New York State are based on trees that have been planted or have escaped from cultivation.

(Wherry et al. 1979), growing in habitats similar to those found in New Jersey. It seems improbable to me that the distribution of native populations of *Cercis* stops abruptly on the Pennsylvania side of the Delaware.

The farther away you move from the Delaware River Valley, the more difficult it is to distinguish native populations from the adventive or planted. While *Cercis* is abundant as an ornamental planting statewide, I see no evidence indicating that the species successfully escapes from cultivation. Planted trees may persist long after cultivation and may even spread locally through suckering, but cultivated plants do not appear to readily colonize suitable natural habitat. In a rather isolated area of Sussex County I found a single, very large tree near an old foundation, growing with *Syringa* and other obvious cultivars. Although the yard in which it had been planted had succeeded to woodland, there was no evidence of sexual or asexual reproduction. There are also a few trees growing in a wooded ravine on the Busch Campus of Rutger's University, Middlesex County, which look native enough, but according to David Fairbrothers (pers. comm.), they have spread from trees planted around the College President's residency which overlooks the ravine. Not too far from this ravine is a single large redbud growing on the flood plain of the Raritan River. Here it grows with native species like *Carex grayii*, *Florekea proserpinaciodes*, and *Mertensia virginica*, but also with a planted species of spruce, and a suspiciously out of place *Kalmia latifolia.*

The only other location that I am convinced *Cercis* is native is a Somerset County site, first collected by M. A. Chrysler 8 May 1935 on the east slope of the First Watchung Mountain, 1.3 miles west of Dunellen (CHRB). Chrysler noted it was "frequent (locally?)" and that it "may be native." On 14 June 1989, I drove the designated 1.3 miles west of Dunellen along Route 22 at the base of the Watchung Mountains, and ended up in the middle of a fairly recent housing development where *Cercis* grew abundantly in roadside woods. In subsequent visits, I have found *Cercis* to be exceedingly common here, where in places, it is the dominant species in the subcanopy, and occurs over a mile or so stretch of a steep, wooded, trap rock hillside.

There are other New Jersey specimens for *Cercis*, some of them clearly collected from cultivation, others possibly native, but these all have vague location data and lack any meaningful habitat descriptions.

Ammannia latifolia

Ammannia latifolia is a southern species ranging from northeastern New Jersey, south to Florida, west to Texas, and south through the Caribbean to South America (modified from Graham 1985). Plants from the eastern United States have long been known as *A. koehnei* or *A. teres*, but both names are now reduced to synonymy: *A. koehnei* under *A. latifolia*, and *A. teres* under *A. coccinea* (Graham 1985). Britton (1891) maintained that the petalous plants from the eastern United States (i.e., *A. koehnei*) were distinct from the more southern apetalous *A. latifolia.* Graham (1985) has shown this character to be variable and noted that petalous and apetalous plants are found in the same population, sometimes even on the same plant.

The type locality of Britton's *A. koehnei* has been given as the Hackensack Marshes, New Jersey (Britton 1891; Stone 1912; Taylor 1915; Fernald 1936) but the actual notation on the label of the type specimen (*Leggett s. n.*, NY) appears to be Hackensack "Flat" or "Flats." In any case, the locality data is so vague that the exact county remains uncertain. The

Hackensack Meadowlands (as the area is now known) is extensive, and occurs along the Hackensack River in both Bergen and Hudson counties. The extensive Atlantic white cedar wetland that once occurred here was largely gone by 1896 as a result of ditching, diking, logging, burning, and more recently, through filling and salt water intrusion (Sipple 1972; Schmid 1987). Today it is hard to imagine that these wetlands dominated by *Phragmites australis*, punctuated here and there by landfills, oil refineries, and warehouses, once supported *Ammannia latifolia* and the botanical diversity described by Harshberger and Burns (1919). Until *Ammannia latifolia*'s rediscovery in 1990, the Hackensack Meadowlands was its only documented New Jersey location where it was last collected there on 28 July 1868.

On 12 October 1990, I discovered a small colony of *Ammannia latifolia* in a brackish tidal marsh along the south side of the Tuckahoe River, ca. 2 miles north of Middletown, Cape May County. On 16 October 1990, a total of 620 plants were counted scattered over a distance of nearly a quarter of a mile. The largest concentration was of 313 plants growing in a somewhat circular open flat having patches of bare organic mud covered with one or two inches of water. The flat was bordered by a zone of *Cyperus* sp. and *Scirpus pungens* which graded into a dense zone of *Spartina cynosuroides* on the river side, and a zone of *Typha angustifolia* and *Phragmites australis* on the upland side. Other associated species included *Atriplex prostrata*, *Kosteletzkya virginica*, *Samolus valerandi*, *Lythrum lineare*, *Aster tenuifolius*, *Pluchea odorata*, and *Solidago sempervirens*. Although I found *Ammannia* growing in areas of much denser vegetation (i.e., pure stands of *Phragmites*), it was most abundant in areas of open, low vegetation, particularly on, and around muskrat middens and runs. Plants were found in all stages of development from very young plants, to plants in bud, flower (petals pale lavender and falling with the slightest touch), and with mature fruit capsules.

In 1991, Stephen Field informed me that he had found *Rotala ramosior* in a salt marsh in the Tuckahoe River drainage, Cape May County. My suspicion that this plant was more likely *Ammannia latifolia* (*Rotala* is not a salt marsh species) was confirmed on 18 July 1991 at Stephen's site along Cedar Swamp Creek, a major tributary of the Tuckahoe River, which is about three miles southeast of my location. Later Stephen told me of another population of *Ammannia* that he had found on 10 August 1991 at a site a little north of his first location. Apparently, *Ammannia latifolia* is well established in the marshes along the lower Tuckahoe River.

Fernald (1936) stated that "North of Florida typical *Ammannia* [*latifolia*] is a very localized plant." Although more locations are known today then were known in Fernald's day, his statement is still an accurate assessment. It is known from five or fewer extant occurrences in both New Jersey and Maryland, from between five and twenty locations in North Carolina (Alan Weakley pers. comm.), and apparently absent from Delaware (Tatnall 1946) and South Carolina (Radford et al. 1968). It seems to be most abundant in Virginia where its recorded from twelve counties (Harvill et al. 1986).

Rhexia mariana var. ventricosa

The relationships of this taxon are obscure, and its distribution north of Virginia is poorly known. Originally described as a species by Fernald and Griscom (1935), and so recognized by James (1956), Kral and Bostick (1969) reduced it to a variety of *R. mariana*. More recently Cronquist (Gleason and Cronquist 1991) synonymized it with *R. interior*. Regardless of nomenclatural preferences, the taxon is distinctive, and is easily recognized in the field. Its general morphology suggests an intermediate between *R. mariana* var.

mariana and *R. virginica*. Its stem is square with all faces nearly equal in width like that of *R. virginica*, but essentially wingless like *R. mariana* var. *mariana*. It has the long, horizontally spreading rhizomes of *R. mariana* var. *mariana*, but lacks the tuberous thickenings of *R. virginica*. Mature hypanthiums are longer necked than *R. virginica*, and are more like those of *R. mariana* var. *mariana*. The seeds of *R. mariana* var. *ventricosa* have concentric rows of close-set papillae, which are unlike either *R. virginica* or *R. mariana* var. *mariana* (Fernald 1935; James 1956; Kral and Bostick 1969).

Rhexia mariana var. *ventricosa* is restricted to the eastern United States, occurring from southern New Jersey, south, mostly along the Coastal Plain, to South Carolina (James 1956; Kral and Bostick 1969). It is apparently rare in New Jersey, Delaware, and Maryland, but field work may show otherwise. Part of the reason that *R. mariana* var. *ventricosa* may be overlooked north of Virginia is that until recently it has not been widely known that it is a part of the flora of these states. Fernald (1950) listed it as occurring north only to Virginia, Gleason (1952) synonymized it under *R. mariana*, and none of the checklists of New Jersey's flora have included it (Hough 1983; Anderson 1989; Schmid 1990).

On 15 October 1991, Andy Windisch and I found *R. mariana* var. *ventricosa* at an abandoned sand pit at Pierces, just north of Kay Pond in Cape May County. There were hundreds of plants growing in open, damp sand of an oak/pine woodland. Scattered here and there in the colony were plants of *R. virginica*, but unlike the plants of *R. mariana* var. *ventricosa* which was either still green or beginning to turn a brilliant yellow-orange, *R. virginica* had already turned deep red and the majority of plants had already dropped their leaves. In contrast, *R. mariana* var. *ventricosa* was still in good shape and even a few flowering plants were located. Not too far away, we found an extensive colony of *R. mariana* var. *mariana* which was in about the same condition as var. *ventricosa*. Comparing the three taxa together in the field, the differences between them were apparent; something that is not always as easy to do in the herbaria.

Prior to this relocation, *R. mariana* var. *ventricosa* was last collected in New Jersey on 18 September 1909 by K. K. Mackenzie, which is the basis for the New Jersey record cited in James (1956) and Kral and Bostick (1969).

Cornus amomum var. schuetzeana

On 10 September 1990, while searching for a rare *Cuscuta* that had been collected from the floodplain along the Delaware River, northwest of Columbia, Warren County, I found a tangled thicket consisting mostly of a shrubby, unknown species of *Cornus*. It turned out to be *C. amomum* var. *schuetzeana*. I later discovered that it had been collected 42 years earlier about nine or ten miles south of my location (Warren Co.: alluvium, 1-2 mi SW of Belvidere, 9 Jul 1948, *R. L. Schaeffer, Jr. s. n.*, PH). This taxon has missed being recorded as occurring in New Jersey in the recent checklists of the state's flora (Anderson 1989; Hough 1983, Schmid 1990). It is recorded for New Jersey by (Fernald 1950), possibly based on the PH specimen.

The nomenclature for this species is complicated with four different names having been applied to it within this century: *C. amomum* ssp. *obliqua* (Wilson 1965; Kartesz and Kartesz 1994), *C. amomum* var. *schuetzeana* (Rickett 1934; Gleason and Cronquist 1991), *C. obliqua* (Fernald 1950), and *C. purpusii* (Rickett 1945; Gleason 1952). Despite the nomenclatural problems, there is general agreement that the taxon is taxonomically significant and distinct, except for some probable hybrids involving *C . amomum* var. *amomum* where their ranges overlap.

The var. *schuetzeana* is more northern and western in distribution, occurring from New Brunswick south to New Jersey and Virginia (Harvill et al. 1986), then west and south to North Dakota, Kentucky, Arkansas, and Oklahoma (modified from Fernald 1950; Wilson 1965). The var. *amomum* is more southeastern in its distribution, occurring from Georgia west to Mississippi, northeast to southern Maine, and then west to southern Ohio and Indiana (Fernald 1950; Gleason and Cronquist 1991). The New Jersey specimens that I collected are unambiguous and show none of the transitional characters reported to sometimes occur in eastern specimens (Rehder 1910; Rickett 1945; Wilson 1965). The Atlas of the Flora of Pennsylvania (Wherry et al. 1979) shows a location dot along the Delaware River in Monroe County that is nearly opposite of where I made my collection. With additional searching it is possible that new locations for *C. amomum* var. *schuetzeana* will be found along this portion of the Delaware River.

Linum intercursum

On 17 August 1990, Ted Gordon and I relocated what I take to be Stone's 1913 location for *Linum intercursum*: Burlington Co.: Symms Place, 3 mi W of Cedar (Warren) Grove, 29 Jul 1913, *W. Stone 14525*, PH (Snyder 1993). It was locally abundant at this site and grew mostly in the drier portions of a recently burned pitch pine lowland forest. Nearby, we found scattered plants growing in an open meadow, which had been several years ago, a cultivated blueberry field. *Linum intercursum* was last collected at this site in 1939 (11 Aug 1939 *B. Long 53083*, PH) which apparently is also the last time it had been collected in the state.

The species is distributed along the Atlantic Coastal Plain from Massachusetts south to North Carolina then inland to Tennessee, with disjunct occurrences in Indiana (Rogers 1963). Although commonly occurring in moist soil of oak or pine woodlands (Rogers 1963) it also occurs in dry soil. In Pennsylvania, it has been collected on serpentine barrens (John Kunsman pers. comm.). Its distribution in New Jersey is predominantly Coastal Plain where it has been collected from widely scattered locations in most of the Coastal Plain counties. Many of these collections record the habitat as dry sandy woods or dry oak and pine scrub, but a few collections have been from wetland habitats, the most unusual being from the sandy, clayey border of an intermittent pond (*Long 47083* PH).

Despite its broad range and an abundance of seemingly suitable habitat, the species is apparently rare throughout much of its range, with it currently being tracked at some level of rarity in Massachusetts, Connecticut, Rhode Island, New York State, Indiana, Pennsylvania, New Jersey, Delaware, Maryland, and North Carolina (The Nature Conservancy's Biological and Conservation Database). While populations certainly have been lost through the development of its habitat, fire suppression has also been suggested as a significant factor contributing to the species current rarity throughout most of the eastern part of its range (Bruce Sorrie pers. comm.; Alan Weakley pers. comm.).

Pycnanthemum clinopodioides

Pycnanthemum clinopodioides has the most restricted distribution of any *Pycnanthemum* that occurs in the northeastern United States. Grant and Epling (1943) record it from 14 counties in eight states (Massachusetts, Connecticut, New Jersey, New York, Pennsylvania, Maryland, West Virginia, North Carolina) and the District of Columbia. At NY there is an undated specimen collected from Green County, Indiana (*A. Wood, s. n.*), which, if it is correctly labeled, is a remarkable disjunct. It also has been reported from Delaware[2]. Although some additional counties have been subsequently added to those reported by Grant and Epling (1943), the species remains extremely local or rare throughout its range (The Nature Conservancy's Biological and Conservation Database). The species was first described by Torrey and Gray in 1842 based on specimens collected in New Jersey and from the vicinity of New York State (Grant and Epling 1943).

In general aspect this species suggests a narrow leaved *Pycnanthemum incanum*. It is variable in habit, indument, amount of branching in the inflorescence, and the size and the degree of unequalness of calyces, but constant in leaf shape and the presence of short, hooked hairs on the stems. Leaf shape is lanceolate, often narrowly so, with median leaves predominantly under 2 cm, rarely as wide as 2.7 cm. Both surfaces of the leaves are green, except for the leaf-like bracts subtending the inflorescence, which may be either green, or less frequently, canescent on the upper surface, especially near the base. By contrast, the leaves of *P. incanum* are ovate, often broadly so, to oblong-ovate, and up to 5.5 cm wide (fide Fernald 1950), with many of the upper leaves strongly canescent above. *Pycnanthemum clinopodioides* can be separated from the narrow leaved species in the genus by its more open, distinctly branched inflorescence, bilabiate calyces, which are typically margined with few to several long, multiicelled trichomes, and the presence on the stem of both long, spreading hairs, and minute, strongly downwardly or upwardly curved hairs, many of which have the tips pointing down toward the face of the stem, thus looking like a tiny inverted "J" or "U."

Gray (1848) considered *P. clinopodioides* to be intermediate between *P. incanum* and *P. torrei*. Grant and Epling (1943) saw *P. clinopodioides* as the species connecting what they recognized as the *Incanum* Phylad with the *Virginianum* Phylad. And, although they recognized *P. clinopodioides* as a valid species, they did note that the species "is rather variable in habit and suggests strongly a hybrid origin between a member of the *incanum* group and one of the narrow leaved species, such as *P. verticillatum*" (Grant and Epling 1943). This statement apparently serves as the point of departure for those authors since Grant and Epling who have dismissed *P. clinopodioides* as being of hybrid origin (Gleason 1952; Gleason and Cronquist 1963), or have simply reduced it to synonymy (Radford et al. 1968). Current treatments, such as Kartesz and Kartesz (1994) and Cronquist (Gleason and Cronquist 1991) recognize *P. clinopodioides* as a species.

In recent years, I have come to the opinion that *P. clinopodioides* is a distinct species and I have spent many hours in the field trying to find it. Most of my efforts were concentrated around six historical sites in Passaic, Bergen, Hunterdon, Mercer, and Gloucester counties where the most recent specimen is: Gloucester Co.: Jennings. 2 Aug 1891, *C. D. Lippencott s. n.* CHRB). This past winter, as I was going through my specimens of *Pycnanthemum* checking for misidentifications, I found that I had collected *P. clinopodioides* on 20 July

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[2] Tatnall (1946) cites two records for Delaware. The first is a specimen at PH that was collected 18 August 1876 by A. Commons from Wills Rock, Wilmington, New Castle County. Since this specimen is not now in the *P. clinopodioides* folder at PH and because Delaware is not included in the range given by Grant and Epling (1943), it may have been reidentified as something else. The second record is based on a specimen, which according to Commons, was collected by Canby in 1872 "near Swayne Station, W. & N. R. R." What I take to be this specimen is at NY: New Castle County: Dry hills near Center Station, Aug 1872, *W. M. Canby s. n.* Originally identified as *P. clinopodioides*, this specimen lacks the characteristic hooked pubescence of that species and I have identified it as *P. torrei*.

1980 from open woods on a limestone ridge at Johnsonburg, Warren County, but had identified it as "*P. verticillatum*." When I revisited this site, the once open ledge had succeeded to a shrubby thicket, and I could not find *P. clinopodioides*. However on 9 October 1992, Tom Breden and I discovered a colony of 67 plants in full sun in a limestone glade at Sterling Hill Mine, Ogdensburg, Sussex County.

Pycnanthemum torrei

The critical couplets in keys in Gleason (1952), Gleason and Cronquist (1963), and Gleason and Cronquist (1991) all break on the same variable character: whether or not the upper surfaces of the leaves and bracts are glabrous or nearly glabrous. Specimens of *P. torrei* collected throughout its range at CHRB, NY, and PH, illustrate this variable character. The upper surface of the stem leaves below the inflorescence of *P. torrei* are glabrous, except for occasional scattered hairs. The leaf-like bracts subtending the inflorescence are commonly minutely hairy over the entire upper surface, or less frequently, with hairs largely confined to the base of the leaves. In some specimens, such as the isotype (New Jersey: Mercer County: Princeton Jul 1831, *J. Torrey s. n.*, NY) and Mackenzie's number 266 (New Jersey: Essex County: Milburn, 12 Jul 1903, NY), the bracts subtending the inflorescence, as well as several of the leaves below these, are densely short hairy over the upper surfaces. The inner faces of the involucre bracts, both the broader outer, and the narrower inner, are also variable in pubescence. Frequently the inner faces of the bracts are essentially glabrous as in the isotype, but hairs can be also just on the upper half (Delaware: Kent Co: Felton, July 1874, *W. M. Canby s. n.*, PH), the top, bottom, and midvein (Virginia: South Hampton Co.: Near Raccoon Creek, north of Mill Neck Church, 9 Jul 1940, *M. L. Fernald* and *B. Long 12462*, PH), or even hairy throughout, as in the above cited Mackenzie specimen. The outer faces of the bracts are always hairy, sometimes densely so. Bentham's (1832) type description makes no distinction between the inner or outer faces, "*Calyces et bracteae molliter villosi.*"

Using the keys in the above manuals, some or many specimens (depending on how you interpret modifiers like "evidently," "nearly," or "few") will run to *P. verticillatum*. The most reliable characters by which to distinguish *P. torrei* from *P. verticillatum* are the shape and size of the calyx lobes. In *P. torrei*, the lobes are lanceolate, commonly attenuate to a slender point, and 1 mm to 1.5 mm in length (occasionally a little longer). The calyces of *P. verticillatum* are narrowly deltoid and 0.7 mm to 1 mm in length. Depauperate, or immature specimens of *P. clinopodioides* can be similar to *P. torrei*, but these can be readily identified by the distinctive pubescence of their stems (described previously). The stems of *P. torrei* are commonly sparsely hairy on the faces with very short hairs, which are either nearly perpendicular to the stem or downwardly or upwardly directed, being slightly bent, mostly at, or above the middle (The short hairs of *P. clinopodioides* are mostly bent at or below the middle). Longer hairs occur primarily along the edges of *P. torrei*'s stem, but their length and abundance vary, especially towards the western and southern portions of its range. These more densely hairy phases have been described as either *P. leptodon* Gray or *P. torrei* Benth. var. *leptodon* (Gray) Boomhour, but as with many of the taxa of *Pycnanthemum*, pubescence is quite variable, and shows little geographical or taxonomical consistency.

The distribution of *P. torrei* is predominantly eastern, like that of *P. clinopodioides*, but extends farther west and south then does that species. Typical material has been collected or reported from southern New Hampshire (Hodgdon and Steele 1972), southeastern

Connecticut (NY), southeastern New York State (PH; NY), eastern Pennsylvania (NY; PH), New Jersey (BK; CU; CHRB; GH NY; PH), Delaware (NY; PH), Maryland (Grant and Epling 1943), District of Columbia (Grant and Epling 1943), southeastern Virginia (NY; PH); West Virginia (Grant and Epling 1943), North Carolina (PH), South Carolina (Grant and Epling 1943), to northern Georgia (NY; PH). Fernald (1950) reports it from Ohio and Arkansas, but these states are not included in Grant and Epling (1943).

Although considered by Grant and Epling (1943) to be a distinctive and fairly uniform species, there are specimens of *P. torreyi* from the Midwest (Illinois, NY, Missouri, NY, Kansas, NY, and Indiana, IND, and occasionally elsewhere (New Jersey, PH, Pennsylvania, NY, PH), which seem to be intermediate between *P. torrei* and some of the other narrow-leaved species. Frequently the calyx lobes of these intermediate specimens are ± deltoid shaped (like *P. verticillatum* or *virginianum*) but with acuminately to attenuately prolonged tips (like *P. torrei*). Although these specimens will key to *P. torrei*, they are at best, atypical. While many of these specimens have been annotated as *P. torrei* by Grant or Epling, they may be, as suggested by these authors (1943), of hybrid origin, possibly involving *P. flexuosum, P. virginianum,* and *P. verticillatum*. Clearly more study is needed to resolve the identity of these problematical specimens.

Pycnanthemum torrei is rare throughout its range with nearly every state Natural Heritage Program tracking it as a conservation priority (The Nature Conservancy's Biological and Conservation Database). The greatest concentration of collections apparently are from the area of southern New York State, northern New Jersey, and eastern Pennsylvania. At the herbaria examined for New Jersey specimens there are 25 specimens representing at least 12 distinct localities in nine counties (Passaic, Bergen, Essex, Morris, Hunterdon, Middlesex, Mercer, Monmouth, Gloucester). All but seven of these specimens were collected during the latter part of the last century. The most recent collections were both collected in 1931: Passaic Co.: High Mountain, Haledon, 13 June 1931, *H. K. Svenson 4530*, GH, NY; Hunterdon Co.: 1 mi north of Byram, G. *A. Loughridge* and *M. A. Chrysler s. n.*, CHRB. On 15 August 1990 I relocated Svenson's High Mountain site and on 17 July 1991 I discovered a new site on the Ramapo Mountains, northwest of Darlington, Bergen County. At both sites *P. torrei* was growing in open, dry, rocky glades in oak/hickory forests on slopes near the summits of south facing hillsides. The substrate at the Bergen County site is granitoid gneiss and at the Passaic County site it is trap rock. Clearly in the northeastern portion of the range (and apparently elsewhere) *P. torrei* often grows in substrates rich in iron and magnesium such is found in mafic formations like trap rock or diabase. Half of the 12 New Jersey locations are on trap rock or diabase, and the species also has been collected on similar substrates in Connecticut (Les Mehrhoff pers. comm.), New York State, Pennsylvania, Maryland (Dan Boone pers. comm.), and North Carolina (Alan Weakley pers. comm.).

Carex amphibola var. amphibola (sensu Fernald)

On 3 July 1991, I found numerous patches of this taxon on the slope of a wooded diabase hillside, approximately 0.4 mile southeast of Brookville, Hunterdon County. Specimens were sent to Robert Naczi, who confirmed the identification.

Fernald (1950) recognizes four varieties under *Carex amphibola*: var. *amphibola*, var. *globosa*, var. *rigida*, and var. *turgida* (= *C. grisea*). All except var. *globosa* occur in New Jersey. The differences between these varieties, seemingly distinct on paper, are sometimes difficult to apply with consistency in living or dried specimens, particularly between the vars. *amphibola* and *rigida*. Consequentially, many of the New Jersey specimens that I have examined have not been identified to variety. The distribution of the varieties within the state is therefore difficult assess at present. In my experience, *C. amphibola* var. *turgida* is the most abundant and widely distributed variety. It is distinctive in its inflated perigynia and wider leaves (up to 10 mm). It is common in floodplain forests, and is found in most of the northern counties and at scattered sites on the Inner Coastal Plain. It is especially abundant along the Delaware River and its tributaries. The var. *rigida* differs in its scarcely inflated perigynia and narrower leaf blades (usually under 10 mm). It seems to occur in more upland habitats than does var. *turgida*. I have found it with some regularity in the rich limestone woodlands of Sussex and Warren counties.

Clearly the rarest taxon we have is var. *amphibola*. Its leaves are typically much more narrow (usually under 4 mm) and the base of the plant and its rhizomes are reddish purple. The base and rhizomes of var. *rigida* are typically brownish, but exceptional specimens, similar to those I collected from Andover Iron Mine, Sussex County, New Jersey, have deep red bases (Robert Naczi pers. comm.). According to Robert Naczi (pers. comm.), typical *C. amphibola* is known from only one other New Jersey collection: Dry wooded bluff, Lambertville, Hunterdon County, 28 May 1921, *K. K. Mackenzie s. n.*, NY). My site is located about 1.5 mile north of Mackenzie's locality. It was growing in association with *C. hirtifolia* and with *C. hitchcockiana*, another rare member of section *Oligocarpae*, particularly in Hunterdon County. Typical *C. amphibola* reaches the northeastern limit of its range in New Jersey and adjacent eastern Pennsylvania (Robert Naczi pers. comm.).

Carex formosa

On 7 June 1990 I discovered a small population of *C. formosa* about 1 mile northeast of Brighton, Sussex County. The plants grew in an ecotonal area located between a fairly open wooded seepage swamp and the base of a low, wooded limestone ridge. In the swamp, *Acer rubrum*, *Fraxinus nigra*, *Quercus bicolor*, *Vaccinium corymbosum*, and *Osmunda cinnomomea* are the characteristic species with *Acer saccharum*, *Ulmus* sp., *Hamamelis virginiana*, *Carpinus caroliniana*, *Juniperus virginiana*, *Symplocarpus foetidus*, *Uvularia perfoliata*, *Carex hirtifolia*, and *Cystopteris bulbifera* frequent along its margin. I counted 19 plants with 55 vegetative shoots and nine fruiting culms scattered over an area of several feet. Additional searches of this site were made on 11 and 12 June 1990 but no new populations were found.

Carex formosa is primarily northeastern in distribution, ranging from southwestern Quebec, south through Vermont, New York State, Massachusetts, Connecticut, to New Jersey, Pennsylvania, and Ohio, then west through southern Ontario, Michigan, Wisconsin, Minnesota, and reaching its western limit in North Dakota (modified from Fernald 1950; Gleason and Cronquist 1991). The species is very uncommon to extremely rare throughout its range, and apparently reaches its greatest abundance in Vermont, where there are 31 total occurrences, all confirmed extant (Bob Popp pers. comm.).

Carex joorii

Fifty clumps of *Carex joorii* with a total of 203 fruiting culms were discovered by Andy Windisch and me, while we searching for intermittent ponds south of the Bennett Bogs Preserve, Cape May County. The pond we were searching for had been destroyed—converted into a detention basin—and the woodland stream draining into had been ditched. A series of wet swales adjacent to stream had also been ditched. It was in the ditch through the former swales that we found *C. joorii* on 10 October 1991. The surrounding woodland is dominated by *Acer rubrum*, *Liquidambar styraciflua*, *Nyssa sylvatica*, and *Quercus phellos*, with

Clethra alnifolia, *Ilex opaca*, *Aronia arbutiflora*, and *Vaccinium corymbosum* the conspicuous understory species. Associated herbs included *Dulichium arundinaceum*, *Scirpus cyperinus*, *Proserpinaca palustris*, and *Triadenum virginicum*.

This large and attractive sedge is an addition to New Jersey's flora and is the only member of section *Pendulinae* known to occur in the state. It is a southern sedge that is apparently extending its range northward along the Coastal Plain. Tatnall (1946) cited four Maryland locations for the Delmarva peninsula, and Hirst (1983) reported a fifth Maryland location on Delmarva. In 1984, Hirst (pers. comm.) discovered *C. joorii* in Delaware, and currently there are six extant occurrences in Delaware (Keith`Clancy pers. comm.). If *C. joorii* is a relative newcomer in New Jersey, it would explain why such a conspicuous sedge has not been previously discovered in an area so well botanized as Bennett Bogs.

Carex louisianica

On 6 September 1991, I found a small colony of *Carex louisianica* growing in Great Piece Meadows on the north side of the Passaic River about 0.7 mile northwest of Two Bridges, Morris County. W. D. Miller collected *C. louisianica* at its only other documented New Jersey location at Islin, Middlesex County (15 Jul 1916, *629*, CHRB, NY, PH). Miller's locality is on the southernmost edge of the Piedmont, just north of the Coastal Plain, and immediately north of the terminal moraine (Wisconsin Stage). It was last collected there in 1918 by Mackenzie (28 Jul 1918, *s. n.*, NY). This site appears to have been destroyed by the intensive urbanization that has taken place in this part of central New Jersey.

Carex louisianica is of southern affinities occurring predominantly on the Atlantic Coastal Plain from Maryland, south to Florida, then west to Texas, and northward in the Mississippi drainage to Illinois, Indiana, and Missouri (Gleason and Cronquist 1991, Goodfrey and Wooten 1979). It is disjunct in glaciated northeastern Ohio (Braun 1967; T. Reznicek pers. comm.) and northern New Jersey, being apparently absent (or at least, undocumented) from the rest of Ohio, Delaware, and the southern half of New Jersey. The Two Rivers, New Jersey population is about 25 miles north Miller's Islin site, and is nearly 200 miles northwest of the northernmost Maryland record in Harford County (Gene Cooley pers comm.).

The colony appears to have been derived from a single clone, growing in a patch about five by five feet. I counted thirty-five fruiting culms and many more vegetative plants. The habitat is a broad floodplain forest dominated by an open canopy of *Quercus palustris*, *Liquidambar styraciflua*, *Fraxinus americana*, and *Acer rubrum*. *Carex lupilina* and *C. typhina* grew immediately adjacent to *C. louisianica,* with *C. typhina* forming extensive colonies with thousands of plants, scattered throughout the flood plain. Isolated clumps of *C. grayi* grew here and there. Nearby was large linear swale dominated by *Zizania aquatica* and *Bidens laevis*.

These woods are reminiscent of many Coastal Plain lowland forests that I've been to in southern New Jersey. Places like Riddleton and Muttontown Woods in Salem County, Lannings Wharf in Cumberland County, or even the Pigeon Swamp in Middlesex County. These are places that I have looked for *C. louisianica*, and these are places that I'd expect to find it—not along the Passaic River in the ancient remains of Glacial Lake Passaic.

ACKNOWLEDGMENTS

I thank curators at BK, CHRB, CU, GH, IND, NY, and PH, particularly Patricia Holmgren, Lewis Johnson, Janice Meyer, and Ernie Schuyler for arranging loans. The late

Arthur Cronquist, Bob Kral, Rob Naczi, and Tony Reznicek confirmed some of my identifications. David Fairbrothers made available some difficult to obtain references. John Kartesz helped with several nomenclatural matters. Larry Morse and Christa Russell provided information from The Nature Conservancy's central databases. Tom Breden, Leo Bruederle, Roger Johnson, Jim Stasz, and Howard Wildman transcribed much of the herbaria label data. Joe Arsenault, Dan Boone, the late Gil Cavileer, Keith Clancy, Steve Clemants, Gene Cooley, Tom Cooperrider, Allison Cusick, Andy Cutko, Stephen Field, Ted Gordon, Tom Halliwell, Frank Hirst, Mike Homoya, David Hunt, John Kunsman, Les Mehrhoff, Richard Micthell, Mike Penskar, Bob Popp, Rick Radis, Bruce Sorrie, and Alan Weakley all helped with various aspects of this paper.

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Bartonia No. 58: 97-100, 1994

The Vegetation of Little Beach Island, New Jersey

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Little Beach Island, Atlantic County, New Jersey, is comprised of approximately 283 ha, and is located in southern New Jersey just north of Atlantic City at 39° 28′ N, 74° 34′ W. It is part of the Edwin B. Forsyth National Wildlife Refuge and includes land known as Dog, Pullen and Little Beach islands. Human habitation of the island during the 20th Century was limited to a fishing village and Coast Guard Station. The village was abandoned around 1940 and the Coast Guard Station was decommissioned in 1942.

Little Beach Island is among the most pristine coastal islands in maritime New Jersey. Since this island has been uninhabited for nearly fifty years, and rarely visited, it may serve as a bench mark to measure the effect of man's impact on barrier islands in southern New Jersey. The objective of the present study is to obtain a record of the vegetation of Little Beach Island.

Beach erosion is especially severe on the western and central portion of the island. Coastal storms erode the protective primary dunes and deposit sand on the inland salt marshes, especially on the western and southern portions of the island. After storm disturbances, the dunes are rebuilt by natural processes and are colonized and stabilized by *Ammophila breviligulata.*

METHODS

The vegetation of Little Beach Island was sampled once every three weeks beginning May 3, 1989, terminating on November 6, 1989. Herbarium voucher specimens of each taxon were prepared and deposited at Edwin B. Forsyth National Wildlife Refuge. The species checklist contains an inventory of the vascular plants of Little Beach Island including native taxa along with naturalized and adventive weeds. All non native species are marked by an asterisk (*). The checklist is divided into three categories: Pinophyta, Magnoliophyta: Magnoliopsida, and Magnoliophyta: Liliopsida. Families and species are alphabetical. Nomenclature follows that of Gleason and Cronquist (1991).

RESULTS

The current vascular flora of Little Beach Island consists of 33 families, 74 genera and 84 species of which 69 are native (Table 1). The Asteraceae with 14 genera and 14 species and Poaceae with 12 genera and 13 species are the largest families. Together they comprise 35% of all genera and 32% of all species. Other large families are the Chenopodiaceae (9 species) and Rosaceae (6 species). Eighteen percent (15 species) of the flora are not native to the United States (Table 1).

Table 1. A statistical summary of the vascular flora of Little Beach Island, New Jersey.

	Pinophyta	Magnoliopsida	Liliopsida	Total
Families	1	26	6	33
Genera	1	54	19	74
Species	1	59	24	84
Native species	1	45	23	69
Introduced species	0	14	1	15

DISCUSSION

The vegetation of Little Beach Island can be classified into three general plant communities: dune community, salt marsh, and immature maritime forest.

DUNE COMMUNITY. Drift and areas of occasional overwash are present on the northern portion of the island. This area is sparsely vegetated by annual plant species most notably *Salsola kali*, *Cakile edentula*, *Sesuvium maritimum*, *Atriplex arenaria*, and *Chamaesyce polygonifolia*. Characteristic perennials include *Honkenya peploides* ssp. *robusta* and *Solidago sempervirens*. Slightly higher rarely flooded portions of the beach are vegetated by the same species and by *Ammophila breviligulata*, *Panicum amarum*, and *Solidago sempervirens*.

The ocean and bay bordering dunes at Little Beach Island are currently undergoing severe erosion. These dunes are currently populated by *Ammophila breviligulata*, *Lechea maritima*, and *Solidago sempervirens*. The sheltered landward side of these dunes is generally vegetated by the same species along with *Toxicodendron radicans*, *Myrica pensylvanica*, and *Prunus serotina*. On sheltered inland dunes in the northeast portion of the island *Hudsonia tomentosa*, *Schizachyrium scoparium*, *Lechea maritima*, *Polygonella articulata*, *Toxicodendron radicans*, *Myrica pensylvanica*, and *Prunus serotina* thrive. The habitat supporting *Hudsonia* is extremely small covering only a few hectares.

MARITIME FOREST COMMUNITY. The maritime forest at Little Beach Island consists of an almost pure stand of *Prunus serotina*, which reaches its best development on the large inland stable dunes. These dunes have been in existance for 300 years (Beall personal communication). *Prunus serotina*, the dominant tree on the secondary dunes at Little Beach Island, has been recognized as a successional species at Island Beach State Park, New Jersey (Martin 1959), at Sandy Hook, New Jersey (Stalter 1974), and at Fire Island, New York (Art 1976; Schulte 1965; and Stalter et al. 1986). The trees near the summit of the dunes are generally short and pruned by salt spray; those occupying the sheltered sides of the dunes where salt spray deposition is minimal are taller, some as large as 10 meters tall. The dune soils are well drained and consist of fine sand with a slight accumulation of organic matter. There are occasional individuals of *Amelanchier canadensis* and *Juniperus virginiana*. *Ilex opaca* is extremely rare; only 7 individuals were observed on the whole island during the growing season of 1989.

Ilex opaca is the dominant tree at the Bayside Holly Forest, Sandy Hook, New Jersey (Stalter 1979) and at the Sunken Forest Fire Island New York (Art 1976; Stalter et al. 1986). The scarcity of American holly at Little Beach Island may be due to the young age of the large stable inland sand dunes as Art (1976) concluded that *Ilex opaca* is the dominant species on portions of Fire Island that have been undisturbed for 200 to 300 years.

SALT MARSH COMMUNITY. The salt marsh community at Little Beach Island occurs along the sheltered inland portions of the island. The vegetation of the low salt marsh is dominated by *Spartina alterniflora.* The higher infrequently flooded salt marsh is populated by *Distichlis spicata*, *Spartina patens*, *Salicornia virginica*, *S. europaea*, *Spartina alterniflora*, *Plantago maritima*, *Aster tenuifolius*, and *Limonium carolinianum.* At the upper marsh boundary, *Iva frutescens* is generally dominant. *Baccharis halimifolia* forms the interface between salt marsh and upland vegetation.

The rarest plants observed at Little Beach Island are *Plantago maritima*, *Sesuvium maritimum*, and *Honkenya peploides.* Their rankings on the New Jersey Natural Heritage Program list (Synder 1992) are: *Sesuvium maritimum* – S2 (imperiled in the state), *Honkenya peploides* – S2 (imperiled in the state), and *Plantago maritima* – S2 (imperiled in the state). *Honkenya* is the dominant plant on the overwash portions of northeast Little Beach Island. Several hundred thousand *Plantago maritima* plants occupy the upper infrequently flooded salt marsh in the southwest portion of the island.

The vegetation of Little Beach Island is similar to that found on other barrier islands in New Jersey especially in the salt marsh and dune communities (Martin 1959). Species diversity here is not as great as that at Island Beach State Park, NJ (Martin 1959), Sandy Hook, NJ (Stalter 1979), Cape May Point State Park, NJ (Sutton et al. 1990), or Fire Island, NY (Stalter et al. 1986), although there is a greater percentage of native taxa here than at the aforementioned areas. The high percentage of native species at Little Beach Island is probably the result of its isolation with respect to man's activities.

CHECKLIST

PINOPHYTA

CUPRESSACEAE: *Juniperus virginiana.*

MAGNOLIOPHYTA –MAGNOLIOPSIDA

AIZOACEAE: *Sesuvium maritimum* (S2).

ANACARDIACEAE: *Rhus copallinum*; *Toxicodendron radicans.*

APOCYNACEAE: *Apocynum cannabinum.*

AQUIFOLIACEAE: *Ilex opaca.*

ASTERACEAE: *Achillea millefolium**; *Ambrosia artemisiifolia*; *Aster tenuifolius*; *Baccharis halimifolia*; *Conyza canadensis*; *Erigeron strigosus*; *Eupatorium hyssopifolium*; *Gnaphalium obtusifolium*; *Hypochaeris radicata**; *Iva frutescens*; *Lactuca canadensis*; *Solidago sempervirens*; *Taraxacum officinale**; *Xanthium strumarium**.

BRASSICACEAE: *Cakile edentula*; *Lepidium virginicum.*

CAPRIFOLIACEAE: *Lonicera japonica**; *Sambucus canadensis.*

CARYOPHYLLACEAE: *Honkenya peploides* (S2); *Spergularia mariana*; *Stellaria media**.

CHENOPODIACEAE: *Atriplex arenaria*, *patula*; *Bassia hirsuta*; *Chenopodium album**, *ambrosiodes**; *Salicornia europaea*, *virginica*; *Salsola kali**; *Suaeda linearis.*

CISTACEAE: *Hudsonia tomentosa*; *Lechea maritima.*

CONVOLVULACEAE: *Calystegia sepium.*

EUPHORBIACEAE: *Chamaesyce polygonifolia.*

FABACEAE: *Trifolium arvense**.

GENTIANACEAE: *Sabatia stellaris.*

LAMIACEAE: *Teucrium canadense.*

MYRICACEAE: *Myrica pensylvanica.*

ONAGRACEAE: *Oenothera biennis.*

PHYTOLACCACEAE: *Phytolacca americana.*

PLANTAGINACEAE: *Plantago maritima* ssp. *juncoides* (S2).

PLUMBAGINACEAE: *Limonium carolinianum.*

POLYGONACEAE: *Polygonum cespitosum**; *Rumex acetosella**, *crispus**.

ROSACEAE: *Amelanchier canadensis*; *Prunus serotina*; *Rosa palustris*; *Rubus allegheniensis*, *flagellaris*.

RUBIACEAE: *Galium aparine*.

SCROPHULARIACEAE: *Linaria vulgaris**, *Verbascum thapsus**.

SOLANACEAE: *Solanum nigrum*.

VITACEAE: *Parthenocissus quinquefolia*.

MAGNOLIOPHYTA –LILIOPSIDA

CYPERACEAE: *Carex albolutescens*, *polystachyos*, *silicea*; *Cyperus strigosus*; *Scirpus pungens*, *robustus*.

JUNCACEAE: *Juncus gerardii*.

POACEAE: *Ammophila breviligulata*; *Cenchrus tribuloides*; *Digitaria sanguinalis**; *Distichlis spicata*; *Elytrigia repens*; *Eragrostis spectabilis*; *Festuca rubra*; *Panicum lancearium*, *virgatum*; *Phragmites australis*; *Schizachyrium scoparium*; *Spartina alterniflora*, *patens*; *Triplasis pupurea*.

RUPPIACEAE: *Ruppia maritima*.

SMILACACEAE: *Smilax rotundifolia*.

ZOSTERACEAE: *Zostera marina*.

ACKNOWLEDGEMENTS

I thank David Beall, Refuge Manager, for permitting me to collect and identify the vascular plants at Little Beach Island, for providing information on the history of the island, and for providing access to the Ranger office; Bob Lamoy, Barbara Hudac, and Mark Steffen for providing me with boat transportation to and from Little Beach Island; Robert C. Meyer for assistance in identifying grasses; Chris Bae and Donato Tramontozzi for assistance in preparing herbarium specimens; Karl Anderson for providing information on rare and endangered plant species in New Jersey; Karl Anderson and Eric Lamont for critically reviewing the manuscript; and to St. John's University for purchasing herbarium supplies.

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Bartonia No. 58: 101-113, 1994

The Vegetation of the Glades Region, Cumberland County, New Jersey

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Since about 1964 the Natural Lands Trust has been acquiring land in Downe Township, Cumberland County, New Jersey, for inclusion in the Fortescue Glades Refuge and the Florence Jones Reineman Wildlife Sanctuary, the former a property of the Natural Lands Trust and the latter a property of the Erdman Trust under management by the Natural Lands Trust. These privately-owned and managed wildlife refuges together comprise an area of approximately 2,000 hectares (approximately 5,000 acres). With ongoing acquisition of contiguous and nearby natural areas by the Natural Lands Trust, the Fortescue Glades Refuge is continuing to increase in size.

The region covered by the present study is an area of 72.6 square kilometers, lying to the east and northeast of the Delaware Bayshore town of Fortescue, and including but not limited to the Fortescue Glades Refuge and the Reineman Sanctuary. It is referred to as the "Glades Region," and is the total shaded area (in either dark or light gray) in Fig. 1. Excluded from the study area are all agricultural and cultural areas, including farm fields currently in use, lawns, built-up industrial, residential, and business areas, and barren piles of mining spoils. However, railroad beds throughout our area as defined by the map are to be included in our study area. Plants known to have been planted in our area for any purposes, such as ornamentation, restoration, or dune-stabilization, and not occurring naturally, e.g. *Pinus strobus* which has been planted extensively around mining pits, will not be further considered in this study.

On current USGS maps, Bear Swamp is not correctly indicated. The section marked "Bear Swamp" is a portion of that which is now known as Bear Swamp West. As understood by residents of the area and my colleagues, Bear Swamp West is the entire section bounded on the south by Methodist Road (County Route 553), a line from Watson's Corner to Frames Corner on the west, Baptist Road and the Central Railroad of New Jersey on the north, and a line from Paynter's Crossing to Turkey Point Corner on the east; Bear Swamp West thus lies entirely within our study area, the Glades Region.

To the east of the Glades Region lies the other half of Bear Swamp, known as Bear Swamp East, now constituting the Bear Swamp East Natural Area, held by the state of New Jersey, and lying, roughly, east of Dividing Creek Road (County Route 555), south of the Central Railroad of New Jersey, west of Whitehead Road, and north of Haleyville Road. Plant communities of Bear Swamp East (for details see Cartica et al. 1988) are similar in most respects to those of Bear Swamp West in the Glades Region. In particular, Bear Swamp East contains an old-growth forest similar in size and species composition to the one in Bear Swamp West but differs from the latter by having a stand of immense trees of *Liriodendron tulipifera.* I know of only one such tree in Bear Swamp West. Moreover, before the gypsy moth kill of the early- to mid-1980s, a number of sizeable trees of *Quercus michauxii* (most or all now dead) had been located in Bear Swamp East. Less sizeable

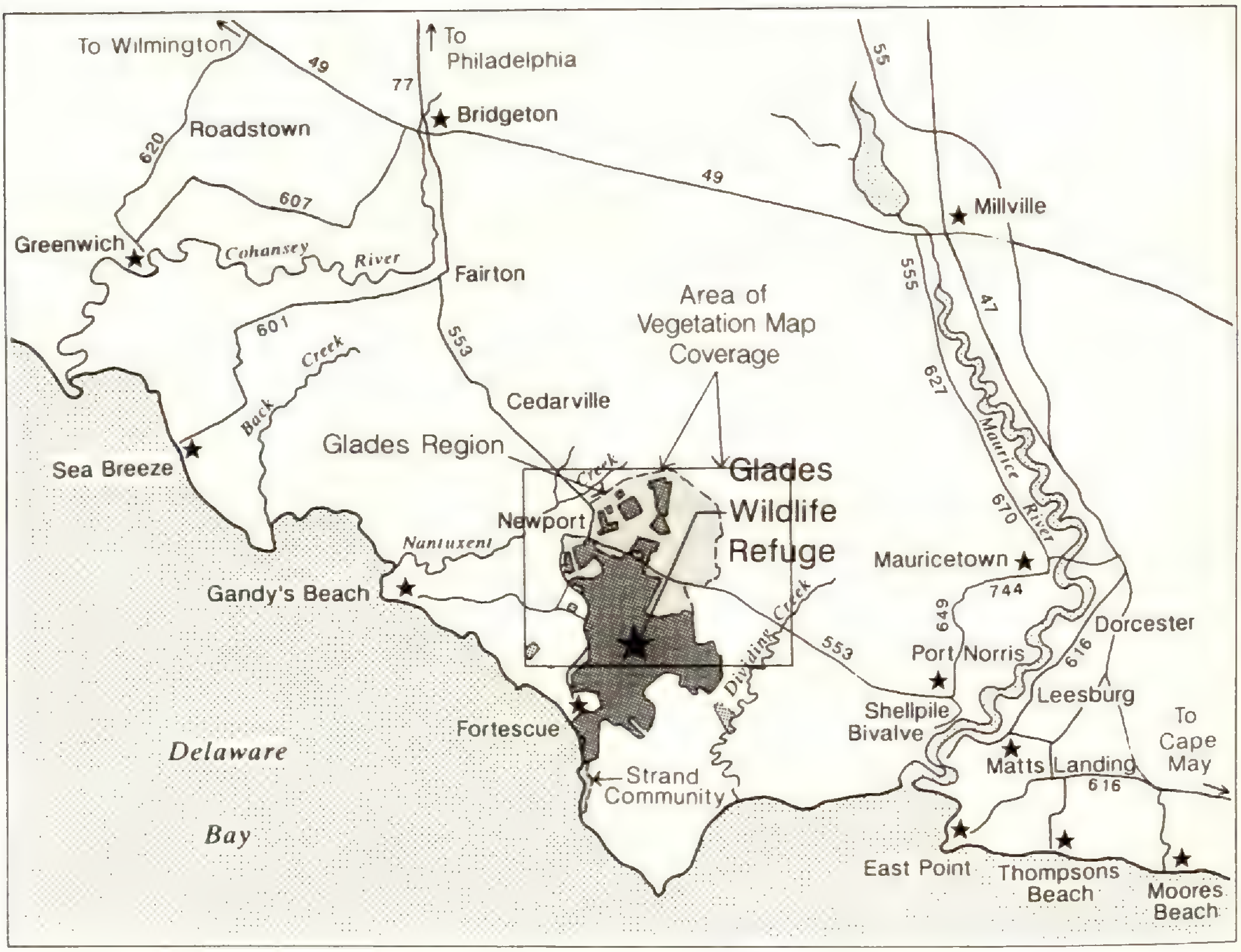

To Wilmington
To Philadelphia
Bridgeton
Roadstown
Millville
Greenwich
Cohansey River
Fairton
Area of Vegetation Map Coverage
Cedarville
Back Creek
Sea Breeze
Glades Region
Glades Wildlife Refuge
Newport
Nantuxent
Mauricetown
Gandy's Beach
Maurice River
Dividing Creek
Dorcester
Port Norris
Shellpile
Bivalve
Leesburg
Fortescue
To Cape May
Delaware Bay
Matts Landing
Strand Community
East Point
Thompsons Beach
Moores Beach
49
77
55
620
607
555
47
601
553
627
670
744
649
616

Fig. 1. Location of the Glades Region.

individuals of *Q. michauxii* were found by myself and others in Bear Swamp West before the kill.

In all plant listings in this paper, names of plants considered by Moore (1989) as not native to Cumberland County will be enclosed in brackets. Nomenclature follows that of Kartesz and Kartesz (1980), except in a very small number of cases. When a name differing from that given in Kartesz and Kartesz is used, the name according to those authors is listed parenthetically.

This study is a qualitative report on a diverse area whose vascular flora has not been the subject of thorough systematic botanical exploration. Especially in the old-growth forest there is need for extensive quantitative studies.

METHODS

I began exploration of the Glades Region in the autumn of 1980, and continued it through 1990. Scattered sites at many points were visited, and their exact locations recorded on USGS maps. At these sites plant species present, especially woody plants, were noted. Specimens of unknown plants were taken for identification and usually deposited in the Herbarium of the Academy of Natural Sciences, Philadelphia, and individual plants belonging to species new to the study or new to the immediate vicinity were photographed. I refer to these sites as "plant data sites." All information for each plant data site was entered in a database, using the dBASE II system: date, site number, species name for each species present, family, and whether or not that species was photographed at that site. At a later time the soil type for that site as determined from the county soil survey (U.S. Department of Agriculture 1978) was also entered.

A computer program was written on this system, enabling me to retrieve the stored data in a manner most useful for vegetation mapping, which was begun in the summer of 1989. Two aerial photographs of the region were used for remote sensing, a 1:400 black-and-white, taken in 1987, and an infrared aerial photograph, obtained from the U.S. Geological Survey (NNAP-80 series, 1:24,000 scale paper print, Wilmington Quadrangle, #441-44, photographed April 1981). The latter was by far the more useful of the two aerial photographs, because on the black-and-white aerial photograph differences among various plant communities were scarcely evident, while on the infrared each community had a distinctive signature.

The procedure used in constructing the vegetation map accompanying this article was basically that outlined by Anderson, Wentz, and Treadwell (1980). Beginning with the broadleaf swamp forest, a site was assigned to mature or old-growth portions of it if *Acer rubrum*, *Nyssa sylvatica*, and *Magnolia virginiana* were all present. The additional presence of *Liquidambar styraciflua* or *Osmunda cinnamomea* or both was regarded as confirmation of the occurrence of this forest type. Moreover, the presence of immense trees in the old-growth area, which I had explored on foot in earlier years, was readily discernible on the infrared, which in many cases clearly showed individual trees, so that old-growth forest could be distinguished from secondary mature forest. Points on the infrared aerial corresponding to plant data sites in these two communities were examined until I could recognize these communities elsewhere on the infrared.

Each of these communities (mature secondary, and old-growth, broadleaf swamp forest) possessed a characteristic appearance, or "signature," which was recognizable elsewhere on the infrared photograph. Species occurring at plant data sites located within these signature areas were checked (using the database and sometimes photographs taken at the site) and in every case I was able to confirm that the sites were located within the predicted community type. The boundaries of these two communities were plotted on the vegetation map, as indicated on the infrared. Ground truthing in the form of onsite checks at several easily-accessible locations confirmed that the community types were correctly determined.

This procedure was applied with variable success to each of the remaining plant communities which had been identified in the previous decade's field work. One difficulty was that spatial transitions between communities were often broad and gradual, particularly between hydric and mesic forests. On the infrared photograph, sharply definable boundaries between these two communities were almost always unrecognizable, and data from field observations seldom provided confident discrimination. For this reason it was decided to add to the vegetation map a category, *transition zone*, to be applied where sharp boundaries between one community and another were indeterminable. In some cases soil data from the Cumberland County Soil Survey (U.S. Department of Agriculture 1978) were used to discriminate between hydric and mesic plant communities, particularly if the infrared map or plant data collected on the ground corroborated such discriminations. (Wet areas usually had a purple or blue cast on the infrared aerial photograph.) In attempting to draw such boundaries on the vegetation map, the following rules were helpful: (1) Muck soils, of the Muck-Atsion-Berryland association, were taken as supporting a predominantly hydric community unless the infrared photograph or ground vegetation data showed that artificial drainage had led to the replacement, on muck, of a mesic community or regime. (2) Soils of the Hammonton-Fallsington-Pocomoke association, which the Soil Survey describes as "moderately well drained to very poorly drained, loamy and sandy soils; on uplands and lowlands," were taken as supporting a predominantly mesic community at a particular point if corroborating evidence for a mesic regime was present in the form of a reddish cast on the infrared, at that point, and provided that plant species recorded at that point, if any, were consistent with such a determination. Frequently a discrimination between predominantly hydric and predominantly mesic communities was difficult or impossible, and "transition zones" were used on the vegetation map.

Another difficulty which was encountered in the construction of the vegetation map was an initial inability reliably to recognize pine-dominated patches on the infrared aerial photograph. A late-winter survey by automobile along back roads in the study area revealed that I had mistaken pine-dominated stands for hardwood stands. The locations of a number of pine-dominated stands were noted and compared with the appearances of these stands on the infrared, with the result that I could recognize the signature of such stands on the infrared. After these were mapped, I inspected some of them from an airplane and from the ground. The result was a high degree of confidence that the vegetation map displays the pine-dominated stands with high accuracy.

In naming the plant communities, I have tried to follow as closely as possible the nomenclature used by McCormick (1979) for the New Jersey Pine Barrens. A number of communities identified in the course of this study do not occur in the Pine Barrens and for these I have tried to employ names in common usage. During the preparation of this paper a preliminary classification of New Jersey plant communities by Thomas F. Breden (1989) appeared, and I have wherever possible inserted into the following text Breden's names for the communities under discussion. In many cases his names are similar to, if not identical with, the names I use and display on the accompanying vegetation map. A list of plants from the study area is being maintained and I invite readers to let me know what they find there so I can make the list more comprehensive and eventually suitable for publication.

This paper and its accompanying vegetation map describe qualitatively a rich and complex mosaic of community types. Because of the complexity of this system, this article is presented as a set of working hypotheses, proposing a classification of the plant communities found to be present, and including a report on their structure, compositions, and distributions. It is hoped that further work in the Glades Region will result in the augmentation, refinement, and modification of the results here presented.

DESCRIPTION OF COMMUNITIES

The Glades Region consists of two landscape types, tidal wetlands and a forested mosaic. The first contains bayshore beach and tidal marsh; the second contains two complexes, hydric or lowland forest and mesic or upland forest. Within these two forest complexes, various types of non-tidal wetlands are present.

The following plant communities have been identified in the Glades Region and are shown on the accompanying vegetation map:

I. *Tidal wetlands landscape type*: (1) Strand community. (2) Tidal marsh, including tidal creeks and ponds.

II. *Forested mosaic landscape type, hydric forest complex*: (3) Non-tidal freshwater marsh. (4) Non-tidal freshwater pond. (5) Herbaceous wetland primary succession. (6) Early broadleaf swamp forest. (7) Pitch pine lowland (hydric) forest. (8) Broadleaf swamp forest, including some old-growth.

III. *Forested mosaic landscape type, mesic forest complex*: (9) Early upland (mesic) broadleaf forest. (10) Upland (mesic) pine forest. (11) Upland (mesic) oak forest. (12) Beech monodominant forest. (13) Heath-shrub community.

(1) STRAND COMMUNITY. Because of limitations in space, the *strand community* or *sand beach community* is not shown on the large vegetation map. However, it is indicated on the accompanying location map. It extends from intertidal beach, over shifting dunes (which may be covered by extremely high tides or storm washover), to the edge of the saltmarsh.

The dominant plant of the strand community is *Ammophila breviligulata*, which covers and stabilizes the dunes. This grass is native to the area and may also have been planted in places to control erosion. Other important members of the strand community are *Amorpha fruticosa*, *Baccharis halimifolia*, *Cakile edentula*, *Cenchrus tribuloides*, *Chamaesyce polygonifolia*, *Cyperus esculentus*, *Iva frutescens*, *Juniperus virginiana*, *Myrica cerifera*, *Phragmites australis*, *Rhus copallina*, [*Salsola kali*], *Solidago sempervirens*, *Spartina alterniflora*, and *Toxicodendron radicans*.

With the slow rise in sea-level the beach is gradually being pushed inland into the tidal marsh, and the strand community stands on what is known as *washover barrier beach*. In places, stands of *Spartina alterniflora* may extend into the bay and from year to year one can observe their rapid diminution and eventual disappearance. Between the dunes and the shoreline, there are places where beach erosion has exposed the long-dead roots of *Iva frutescens*, a shrub which occurs on the boundary between the tidal marsh and the beach, and which sometimes persists among the advancing dunes, marking the line where, years earlier, the beach ended and the marsh began.

Breden (1989) does not appear to list an estuarine (as opposed to marine) strand community, but in floristic composition our strand community appears close to his *marine sand beach community*.

(2) TIDAL MARSH, CREEKS, AND PONDS. Approximately sixty percent of the Glades Region is covered by tidal marsh, including salt or brackish creeks and ponds. *Distichlis spicata*, *Spartina alterniflora*, and *S. patens* are the dominant plants of the tidal marsh. *S. alterniflora* occurs along the edges of creeks and ponds, where it occurs with high vigor or robustness, and also farther from open water, where it is less robust. *Limonium carolinianum* and *Aster tenuifolius* are conspicuous when flowering in the open salt marsh. *Baccharis halimifolia*, *Hibiscus moscheutos*, *Iva frutescens*, *Juniperus virginiana*, and *Phragmites australis* are also important components of the tidal marsh, but occur mainly or exclusively on the boundaries between the marsh and the strand community or between the marsh and the forest.

Phragmites australis requires moist, ecologically disturbed areas free from flooding, where it may become an aggressive pest. Its occurrence in the Glades Region is probably limited to areas of the tidal marsh which have a history of ditching, dumping, digging, or landfill, or which have been compromised by anthropogenic disturbance to contiguous upland. Whether it is spreading into little-disturbed or pristine portions of the tidal marsh is not immediately apparent.

All tidal marshes within our study area belong to Breden's (1989) *salt marsh complex*, except that detailed studies may show that tidal marsh north of Route 553, where Oranoaken Creek flows out of Bear Swamp West, belongs to his *brackish tidal marsh complex*.

(3) NON-TIDAL FRESHWATER MARSH. In the western portion of Bear Swamp West, due north and northwest of Beaver Dam, there are several small fragments of freshwater marsh. There is historical evidence that portions of this section once were under cultivation as cranberry bogs (Daniel O'Connor pers. comm.), and the cranberries which occur there now

may be in part descended from cultivated plants. These marshes are now remote and inaccessible. I visited one of them on 16 October 1983 and found *Chamaedaphne calyculata, Cladium mariscoides, Decodon verticillatus, Dulichium arundinaceum, Juncus canadensis, Proserpinaca palustris*, and *Vaccinium macrocarpon.* The presence of *Chamaedaphne* suggests a successional process taking place. Further study of this and similar communities may reveal that they are referable to Breden's *Pine Barren shrub swamp* community.

(4) NON-TIDAL FRESHWATER PONDS. Within the western half of Bear Swamp West, remote sensing reveals several small freshwater ponds. These bodies of water are probably not natural and most likely are remnants of excavations made early in the present century or earlier, as part of the putative cranberry-growing operation mentioned above. To the best of my knowledge, none of these ponds, which are remote and difficult to find on foot, have been studied botanically; indeed, the same is true of most of the surrounding forests. Further conjectures concerning species which may occur there will be made below in the section on *pitch pine lowland forest.*

A few old farm ponds can be found in places in the Glades Region. In some cases the farms were abandoned long ago and woodland has become established around the ponds. *Acer rubrum* var. *trilobum* and *Magnolia virginiana* are probably the most abundant trees in such wooded stands.

Flooded borrow pits in Bear Swamp West are discussed in the next community type.

(5) HERBACEOUS WETLAND PRIMARY SUCCESSION. In the early decades of the present century, extensive glass-sand mining activities were undertaken in the eastern half of Bear Swamp West. Three large borrow pits were dug, which filled immediately with fresh water. From them a mixture of water and sand was pumped to a processing plant where extraction of the glass-sand took place. Activities at two of these ponds were completed in about 1960, and activities at the third have been completed, or nearly completed, within the past ten years.

Upon abandonment, the water in these ponds has become clear, and a primary successional process has begun on their bare, sandy shores. Many species of herbaceous plants found on the shores of these ponds include *Andropogon glomeratus, Calamagrostis cinnoides, Carex crinita* var. *crinita, C. debilis, C. intumescens, Cladium mariscoides, Decodon verticillatus, Dichanthelium acuminatum* (vars. *acuminatum, densiflorum, implicatum*), *D. scoparium, Drosera intermedia, Dulichium arundinaceum, Eleocharis microcarpa, E. olivacea, E. tenuis, E. tuberculosa, Glyceria obtusa, Juncus acuminatus, J. dichotomus, J. pelocarpus, J. scirpoides, J. subcaudatus, J. effusus* (including var. *compactus*), *Lobelia nuttallii, Lycopodium appressum, L. carolinianum, L. complanatum* var. *flabelliforme, Myriophyllum humile, Nymphaea odorata, Panicum longifolium, Phragmites australis, Pogonia ophioglossoides, Polygala nuttallii, Potamogeton confervoides, P. oakesianus, Rhexia virginica, Rhynchospora alba, R. capitellata, R. macrostachya, Sagittaria engelmanniana, Scirpus cyperinus, S. pungens, S. subterminalis, Spiranthes cernua, Triadenum virginicum, Utricularia cornuta, U. fibrosa, U. geminiscapa, U. purpurea, U. subulata, U. vulgaris, Vaccinium macrocarpon*, and *Xyris difformis* var. *difformis*.

Bog formation has not occurred along these shorelines. However, *Decodon verticillatus*, a well-known bog-builder, is common here.

Phragmites australis has become well established at several places along the shores of these ponds, although it does not seem to be spreading at the moment.

Breden (1989) does not treat "open canopied communities which have formed as a result of anthropogenic ground disturbances such as agriculture or mining," so the early-successional shores of these abandoned borrow pits have yet to be classified under his system. However, McAvoy (1993) describes a coastal strand and barrier island community-type in Delaware, *interdunal wetlands*, whose floristic composition is remarkably similar to that of the early-successional pond shores under discussion. His list includes *Cladium mariscoides*, *Drosera intermedia*, *Euthamia tenuifolia*, *Juncus dichotomus*, *J. scirpoides*, *Lycopodium appressum*, *Scirpus pungens*, *Xyris difformis* var. *difformis*, and *Vaccinium macrocarpon*, which are also found along the shores of the abandoned borrow pits of Bear Swamp West. McAvoy also lists the following mesic species as belonging to the edges of the Delaware interdunal wetland community: *Myrica cerifera*, *Vaccinium corymbosum*, *Aronia arbutifolia*, *Acer rubrum*, and *Liquidambar styraciflua*. These species also occur on the landward edges of the shorelines of Bear Swamp West's borrow pits or occur nearby.

In this rough comparison of signature plant species, the Bear Swamp West shoreline community is similar to interdunal wetland communities in Delaware. Breden's (1989) description of interdunal wetland communities (*coastal interdunal marsh*) in New Jersey differs from the pond shoreline community described here and from interdunal wetland communities in Delaware as described by McAvoy. Further study is needed here.

(6) EARLY BROADLEAF SWAMP FOREST. When fields or other open areas on poorly-drained soils are released to natural succession, the initial woody plant community is a forest of young trees often dominated by *Acer rubrum* var. *trilobum*, which may occur in nearly pure stands. *Liquidambar styraciflua* is also often common in such communities. As these forests mature, many additional woody plant species are recruited. Our findings thus agree generally with those of Hanks (1971) on early hydric woody succession on the Inner Coastal Plain in west-central New Jersey.

(7) PITCH PINE LOWLAND FOREST. Because within the Glades Region no elevations exceed about five meters above mean sea level, the water table is never far below the surface. Wherever the water table is very near or at the surface and forest is present, that forest is by definition hydric, and there are broad transition zones between hydric forests and other vegetation types. Hydric forest in the Glades Region is either broadleaf forest or pine-dominated forest.

In the Glades Region a large number of hydric sites support patches of forest dominated by *Pinus rigida*. I am proposing to classify these patches as *pitch pine lowland forest*. They are probably very similar in etiology and composition to the pitch pine lowland forests of the Pine Barrens described by McCormick (1979). Breden (1989) uses the identical term, *pitch pine lowland forest*, for the same community. However, *Xerophyllum asphodeloides* and *Gaultheria procumbens*, mentioned by McCormick as understory components of pitch pine lowland forests, are apparently absent from our study area, and *Chamaedaphne calyculata* has not been noted by this observer in such situations, although it is present elsewhere in the Glades Region.

In the vicinity of our study area a number of stands of *Pinus serotina* have been reported by many observers. This southern (supposed) species has a disjunct population in Cumberland and Cape May counties in New Jersey. Its taxonomic status is poorly understood, and it may be conspecific with *P. rigida*. In south-central Bear Swamp West, there are trees referable to *P. serotina* and on the Glades I have seen one tree at least suggestive of this species. Remote sensing and direct observation from the air indicate that patches of pitch pine lowland forest are numerous in the potentially very rich western portion of Bear Swamp West, so additional occurrences of trees identifiable as *P. serotina* should be expected there, as well as elsewhere in pitch pine lowland forests of the Glades Region.

Pinus taeda is another rare tree in Cumberland County. There are scattered individuals or small stands of this species not far from our study area, south and east of the town of Dividing Creek, and Dale Schweitzer (pers. comm.) has found a small stand within the Glades Refuge. This tree is often associated with *P. serotina*, so it too should be looked for in the extensive but patchy pitch pine lowland forests of the Glades Region, especially in the western portion of Bear Swamp West where trees resembling *P. serotina* occur.

(8) BROADLEAF SWAMP FOREST. In the Glades Region's hydric forests standing water is often present for at least part of any year with normal rainfall. In our study area, mature forests over such a substrate, when not pine-dominated, fall into the category of *broadleaf swamp forest*, which Breden (1989) denotes by the term *Cape May lowland forest*.

Acer rubrum var. *trilobum*, *Magnolia virginiana*, and *Nyssa sylvatica* co-dominate the mature and old-growth broadleaf swamp forests. Wherever these three species occur together in the Glades Region, the forest type is almost certainly of the present type, and there *Osmunda cinnamomea* will almost always be found. Scattered individuals of *Pinus rigida* and occasional specimens of *Liriodendron tulipifera* occur in some places in this forest.

To the east of the North-south Trail in Bear Swamp West and extending to the shores of the freshwater ponds there is a remnant patch of very old broadleaf swamp forest of approximately 36 ha in area. Here trees attain heights of up to approximately 40 m, and there are at least three strata of woody plants, a closed-canopy "A" story, a "B" story with semi-closed canopy, and a shrub and small-tree layer or "C" story. Ferns, sparse sedges, very sparse forbs, and *Sphagnum*, often with many tree and shrub seedlings, constitute the field layer of this forest. Photographs taken from the opposite shore of one of the ponds before leafing-out in early spring reveal this stratification very well. The complex physiognomy of the forest, the size (and by inference the age) of its largest trees, and the diversity of its woody plants, all suggest strongly that the forest has never been cut, or at most that it has been cut only minimally and selectively. I am provisionally labelling this as an "old-growth" tract of *broadleaf swamp forest*. Final determination of the age and history of this forest awaits core-sampling studies.

In this old-growth forest, the following estimates of size and demographic relationships among the three co-dominant species should be verified by quantitative studies. *Nyssa sylvatica* is the tallest of these trees and is very abundant; *Acer rubrum* var. *trilobum* appears of equal or greater abundance, but although it is an important constituent of the canopy, it seldom if every attains the heights of the taller *Nyssa*. *Magnolia virginiana* is probably somewhat less abundant than *N. sylvatica*, and attains reproductive maturity at considerably less than sub-canopy height. Here it occurs as a large tree, to heights of approximately 30 m (approximately 100 ft), entering the sub-canopy, although in our area it seldom exceeds 10 m in height outside of the old-growth stand. A living specimen of *M. virginiana* had a circumference at breast height (Cbh) of 157.5 cm (5 ft 2 in) in 1982. The previous state record for this species was 4 ft 8 in (Daniel O'Connor pers. comm.). A larger, wind-thrown but still-living, specimen in the old-growth of Bear Swamp West measured 186.7 cm (6 ft, 1.5 in) Cbh in 1986.

In old growth, wherever there is slightly better drainage, *Liquidambar styraciflua* often occurs as a fourth co-dominant with *N. sylvatica*, *A. rubrum*, and *M. virginiana*, even tending to replace *N. sylvatica*; these marginally higher and drier patches are evident to an observer on the ground and show up well on the infrared aerial photograph of the forest, and in these patches *Osmunda cinnamomea* appears to be absent. On the vegetation map these drier patches have been labeled, rather unsatisfactorily, as a transition zone, "broadleaf swamp/upland broadleaf old-growth," even though no mesic old-growth is present in or near the study area. Possibly such patches should be regarded as better-drained portions of the hydric forest, but because on the infrared aerial and on the ground they are so readily distinguishable from the surrounding forest, they have tentatively been considered as a separate category, a transition zone. Broadleaf swamp forest in our regions seems to occur mainly if not exclusively over muck (Muck-Atsion-Berryland association); the "transitional" patches in question may be indicators of inclusions of another soil type, most likely Fallsington sandy loam (Hammonton-Fallsington-Berryland association) (U.S. Department of Agriculture 1978). These patches appear to resemble Breden's *Liquidambar/Acer hardwood swamp*, concerning which, Breden says, the "classification needs work." The status of these patches and their substrate type needs further investigation.

Fagus grandifolia, *Quercus bicolor*, and *Q. michauxii* are three other species found occasionally in old-growth. *Quercus michauxii*, a tree of southern distribution which occurs sporadically in Cumberland and Cape May counties, suffered heavily during the gypsy moth infestation of the mid-1980s, and may now be extremely rare in the Glades Region.

Understory trees and shrubs in mature or old-growth broadleaf forest include *Clethra alnifolia*, *Gaylussacia baccata*, *G. frondosa*, *Ilex laevigata*, *I. opaca*, *I. verticillata*, *Kalmia latifolia*, *Lindera benzoin*, *Rhododendron viscosum*, *Sassafras albidum*, *Vaccinium corymbosum*, *V. vacillans* (*V. pallidum*), *and Viburnum nudum*. A stand of *Chamaecyparis thyoides*, containing only a few small individuals, exists within hydric (but not old-growth) broadleaf forest in Bear Swamp West.

At a few stations within mature and old-growth broadleaf swamp forest, the mistletoe *Phoradendron serotinum* is parasitic on *Nyssa sylvatica*. To the extent of my experience, *N. sylvatica* is the only tree species parasitized by mistletoe in and around the Glades Region, although in Delaware it can be found on a number of additional species, including *Acer rubrum*, which are abundant in suitable habitat in the Glades Region.

A stand (of approximately twenty individual plants) of *Listera australis* occurs in the broadleaf swamp forest of Bear Swamp West.

(9) EARLY UPLAND BROADLEAF FOREST. *Juniperus virginiana* is an important pioneer woody plant on abandoned fields over better-drained soils in the study area. It persists underneath the developing woody canopy, but is not present in the mature forest. *Acer rubrum* var. *trilobum* is a frequent occupant of mesic sites at later seral stages; unlike *J. virginiana* this species often persists indefinitely, being found as a large tree among the dominant oaks characteristic of the *upland oak forest*. Scattered individuals of *Pinus rigida* and *P. virginiana* also occur in this sere and persist into oak-dominance.

(10) UPLAND PINE FOREST. A patch of *upland* or *mesic pine forest* occurs near Beaver Dam, standing on Fallsington sandy loam of the Hammonton-Fallsington-Pocomoke association (U.S. Department of Agriculture 1978) which appears to be moderately well-drained. Being dominated by *Pinus rigida* with *P. virginiana* usually present, this patch resembles upland pine forests of the nearby New Jersey Pine Barrens except for its thick *Ilex opaca* understory. A few similar patches occur elsewhere in our study area. From the soil survey (op. cit.) it appears that all such patches occur on Hammonton-Fallsington-Pocomoke soils, which soils tend to be "moderately well drained to very poorly drained" (op. cit.). Wherever the infrared aerial indicates moderate to good drainage, pine-dominated patches on such soils have been classified as upland pine forest. Among Breden's categories, the most appropriate one for these patches appears to be his *dry pine-oak forest*.

(11) UPLAND OAK FOREST. I have classified about half of the forested area in the Glades Region as *upland* or *mesic oak forest.* Such forest is oak-dominated and stands on better-drained soils. *Quercus alba, Q. falcata, Q. montana, Q. phellos, Q. rubra,* and *Q. stellata* are important species. Scattered among these oaks are *Acer rubrum* var. *trilobum, Liquidambar styraciflua, Nyssa sylvatica, Pinus rigida,* and *P. virginiana*; the understory is often dominated by *Ilex opaca* which sometimes forms thick, insular stands which I have nicknamed "holly islands." Shrubs in the Ericaceae also constitute an important component of the understory of this forest, as they do in the Pine Barrens. Among these are *Kalmia latifolia* and *Clethra alnifolia* (a heath relative). *Gaylussacia* spp. and at least occasionally *Vaccinium vacillans* (*V. pallidum*) are among the important heaths in the understory of this diverse forest.

Except for the presence of the scattered pines, these forests in our area seem to fit Breden's *mesic Coastal Plain mixed oak forest, southern Coastal Plain mesic oak forest subtype.* All of the tree species which Breden (1989) lists as important for this subtype are present: *Quercus falcata, Q. phellos, Liquidambar styraciflua, Fagus grandifolia, Ilex opaca, Cornus florida.* Two additional species, which Breden says reach the northern limits of their ranges, *Q. michauxii* and *Q. nigra,* are present within or close to our study area.

Gypsy moth damage was severe in the upland oak forests of the Glades Region in the mid-1980s. Many oaks, especially in the white-oak group, died from this infestation, and the result today is that there are sunlit openings in the forest, where no doubt succession is occurring. Studies of this succession are needed for their intrinsic interest and their potential importance to land-management.

(12) BEECH MONODOMINANT FOREST. On the edge of one of the abandoned borrow bits in Bear Swamp West is an extensive stand of large trees apparently dominated by *Fagus grandifolia.* The stand is, roughly, a rectangle, of dimensions approximately 360 m by 180 m. From its edge, from the air, and from the infrared aerial photograph, it appears that tall beeches constitute over 50% of the forest canopy. Its etiology is not known. According to Breden (1989), mesic Coastal Plain mixed oak forest may contain beech-dominated stands, of which our beech-monodominant patch is presumably an example.

(13) HEATH-SHRUB COMMUNITY. In northern Bear Swamp West, due north of the ponds and lying just south of the Central Railroad of New Jersey, is a small savannah, a patchy strip of land with scattered trees and a low shrub layer with closed canopy, under one meter in height, containing the following low shrubs of the Ericaceae: *Gaylussacia baccata, Kalmia angustifolia, Lyonia mariana,* and *Vaccinium vacillans* (*V. pallidum*). Trees scattered through this narrow strip include *Quercus alba, Q. coccinea, Q. montana,* and *Pinus rigida.* This strip of savannah is restricted to a single soil type, Downer sandy loam of the Downer series. Its southern boundary coincides almost exactly with the boundary between this soil and an area of muck lying just to the south. Although there is no obvious sign of recent fire in this community, nor is any other explanation known, it is possible that the community is seral and owes its existence to fairly recent anthropogenic or natural disturbance, including fire. The name *heath-shrub community* is tentative, and further study is needed.

DISTURBED AREAS. The present physiognomy and floristic composition of the mature forests of the Glades Region reflect a recent history of minimal anthropogenic disturbance, except where the gypsy moth infestation of the mid-1980s was severe. Yet there are scattered areas comprising perhaps ten to twenty per cent of the forested landscape, where indications of long-abandoned homesites or fairly recent agricultural activity are evident. Occurring in both hydric and mesic situations, successional stages in these abandoned areas range from oldfield to nearly mature forest. A number of weedy plants, some of them alien, aggressive invasives, can be found where fairly recent disturbance has taken place. Indicators of disturbance include *Asplenium platyneuron*, [*Hemerocallis fulva*], [*Ligustrum vulgare*], [*Lonicera japonica*], *Phragmites australis*, and [*Rosa multiflora*]. Other native, woody, successional plants in these seral areas include *Acer rubrum* var. *trilobum*, *Liquidambar styraciflua*, and *Prunus serotina.*

The rare *Polygala mariana* appears here as an opportunist able to establish itself in a disturbed area.

DISCUSSION

As it is to be expected in an area in which anthropogenic disturbance has been minimal, the entire study area is a richly variegated, patchy mosaic, as the vegetation map reveals. In many respects it is comparable to the New Jersey Pine Barrens, the nearest point of which lies a few kilometers to the northeast of Bear Swamp West. McCormick (1979) considers that the upland portions of the Glades Region belong to the "oak-pine fringe area" of the true Pine Barrens. His description of the vegetation of the New Jersey Pine Barrens parallels in several respects what I have found in the Glades Region. In the forested section of our study area which lies inland from the narrow sandy bayshore beaches and the broad tidal marshes I have found a hydric complex and a mesic complex corresponding to the "lowland and upland complexes" identified by him in the Pine Barrens. I have placed these complexes in my "forested mosaic landscape type," to which I have added a "tidal wetlands landscape type" to include the bayshore and adjacent tidal wetlands, a type which of course is absent from the Pine Barrens of the interior.

It is probable that fire in the Glades Region has historically been a major ecological factor as it has in the Pine Barrens (McCormick 1979, Little 1979). I know of no published studies of the ecological consequences of fire in and around the Glades Region paralleling similar studies in the Pine Barrens carried out by Little, but by inference from the results of these studies it is likely that frequent fire has a place in the etiology of patches of pine forest in the Glades Region.

The large stands of *Pinus rigida* in the Glades Region are strongly reminiscent of similar forests of the Pine Barrens, although a major difference in general aspect is that *Ilex opaca* occurs frequently in the understory of the pine forests of the Glades Region. McCormick (1979) states that on the western margin of the Pine Barrens of New Jersey, *P. virginiana* occurs as an old-field tree. In the Glades Region, I have seen that species as a pioneer in disturbed sites, and also as larger specimens in patches of older forest where evidence of recent disturbance is less clear. The scattered patches of forest dominated by *P. virginiana* which I have seen in the study area may belong to Breden's (1989) *Virginia pine-oak forest.*

In oak or oak-pine forests of the Glades Region, all of McCormick's upland oaks are present: *Quercus alba*, *coccinea*, *falcata*, *marilandica*, *montana*, *stellata*, and *velutina*. *Ilex opaca* often dominates the understory, although heaths are often important. Of the herbaceous members of upland forests in the Pine Barrens according to McCormick, *Tephrosia virginiana* is apparently absent, and *Melampyrum lineare* is common especially along paths or in similar disturbed areas.

McCormick (p. 236) suggests that in their vertical structure, the mesic forests in the Pine Barrens could be visualized as a heath forest under a pine or oak forest. In our study area this description is applicable to both hydric and mesic forests except where *Ilex opaca* is a true tree with lowest branches near the ground, rather than a shrub, so we may think of it as occurring above rather than in the heath layer, which seldom exceeds 3 m in height. In old-growth the holly forms a portion of the lowest tree layer. Perhaps the optimal situation in the oldest hydric and even mesic forests is broadleaf, over holly and other small trees, over heath shrubs, except that where the holly forms a monospecific closed understory canopy it creates deep, permanent shade and very little grows beneath it.

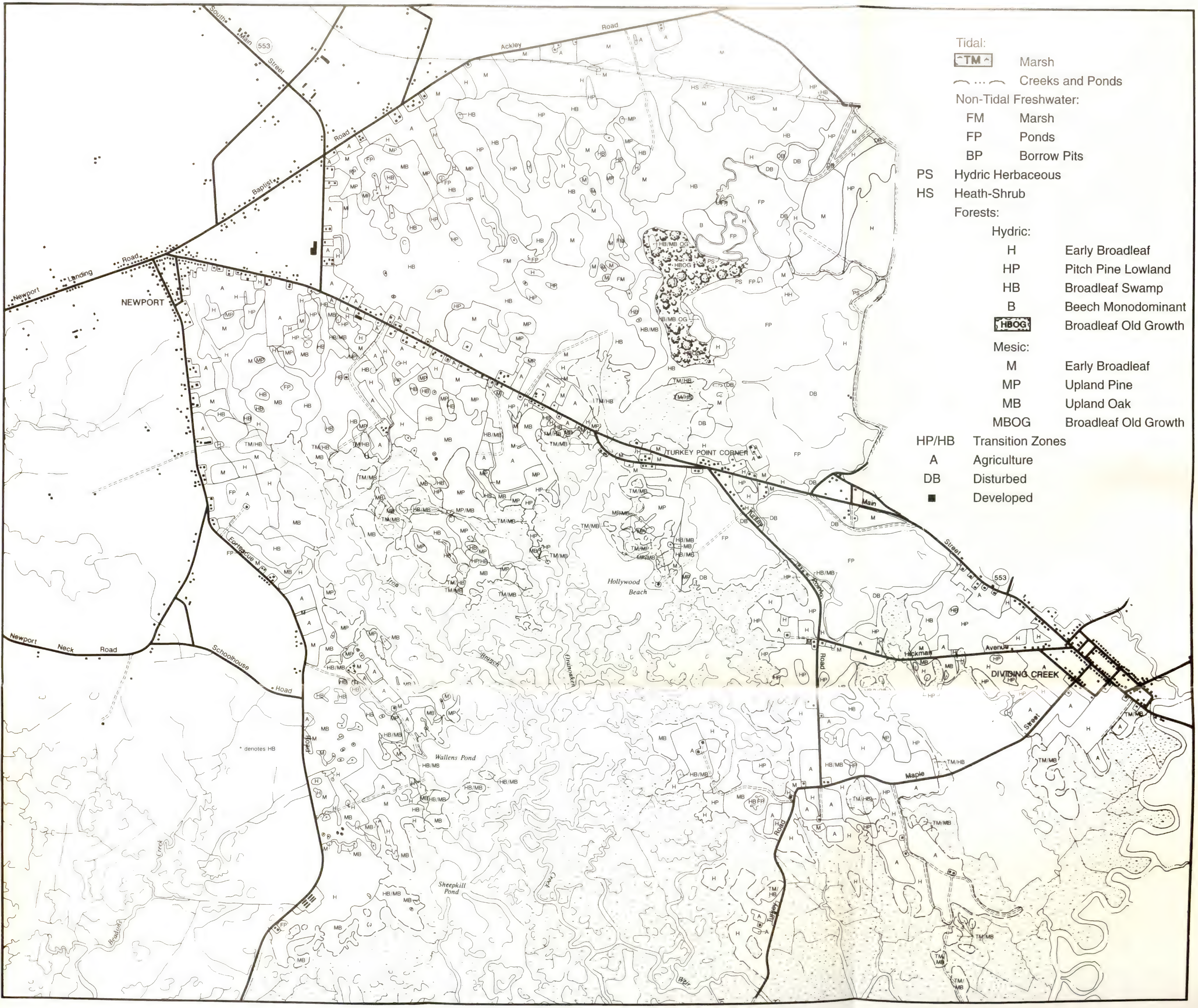
There are several differences between hydric communities in our study area and those of the Pine Barrens as reported by McCormick (1979). Among communities dominated by woody plants there are no cedar swamps within the Glades Region although small numbers of *Chamaecyparis thyoides* are present and two cedar swamps do occur nearby. As with McCormick, *Acer rubrum* (always var. *trilobum*), *Nyssa sylvatica*, *Magnolia virginiana*, and sometimes *Liquidambar styraciflua* are the co-dominants of hydric broadleaf forests in our area, although from visual evidence it is not clear here that, as McCormick suggests for the Pine Barrens, *Acer* is the dominant and the others are associates. As in the Pine Barrens, heaths and heath-allies in our study area include *Vaccinium corymbosum*, *Clethra alnifolia*, *Leucothoe racemosa*, and *Rhododendron viscosum*. Unlike the Pine Barrens, *Lindera benzoin* may form dense stands in the shrub layer of extremely poorly-drained hydric old-growth, and *Ilex opaca* often dominates the understory of hydric forests with heaths secondary in importance (as with mesic forest). As with McCormick, *Pinus rigida* may be scattered through mesic and hydric forests, but *Xerophyllum asphodeloides* (listed as rare in the county by Moore) and *Chamaedaphne calyculata* are completely absent (though *Chamaedaphne* occurs in another habitat). Similarly to the Pine Barrens, *Pteridium aquilinum* is common.

To the best of my knowledge, *Quercus palustris* is uncommon in hydric forests of our study area and *Q. nigra* is absent, the latter a rare species at the northern limit of its range in Cumberland County (Moore 1989). *Quercus phellos* and *michauxii* are present, although, as discussed earlier, *Q. michauxii* has been seriously reduced in numbers by the gypsy moth.

In herbaceous hydric communities within our region, *Nuphar lutea* and *Eriocaulon* spp. are apparently absent. The small patches of freshwater marsh in western Bear Swamp West, easily visible by remote sensing, have been scarcely studied, but may be found to contain some of these species. The presence of *Chamaedaphne calyculata* suggests that these patches of marsh may be "savannahs" (McCormick 1979) being replaced by thickets and swamp forests of *Acer rubrum* var. *trilobum*, *Nyssa sylvatica*, *Magnolia virginiana*, and *Vaccinium corymbosum*, all of which are abundant in the vicinity. As noted above, communities in Bear Swamp West dominated by *Chamaedaphne* may belong to Breden's (1989) *Pine Barren shrub swamp* community type. The presence of *V. macrocarpon* in the marsh community reinforces the local tradition that a cranberry-growing operation existed in this western portion of Bear Swamp West long ago.

Similar forests to the beech monodominant community in Bear Swamp West are common in the Piedmont and are not unknown in the New Jersey Coastal Plain. Of the Inner Coastal Plain, Robichaud and Buell (1973, p. 210) report, "Near the Delaware River in Camden County almost pure stands of beech trees have developed and here, as in North Jersey, the beech appears to propagate itself by root sprouts." Another beech-dominated forest, similar to that in Bear Swamp West, lies in Bear Swamp East. Cartica, Niles, and Petrongolo (1988) describe this beech hardwood forest as follows and a map accompanies their description:

> American beech dominates the canopy of approximately 125 acres which also commonly includes white oak, sweet gum and red maple (Terrestrial Environmental Specialists, Inc., . . .) . . . . Field examination of this

Tidal:
TM Marsh
Creeks and Ponds
Non-Tidal Freshwater:
FM Marsh
FP Ponds
BP Borrow Pits
PS Hydric Herbaceous
HS Heath-Shrub
Forests:
Hydric:
H Early Broadleaf
HP Pitch Pine Lowland
HB Broadleaf Swamp
B Beech Monodominant
HBOG Broadleaf Old Growth
Mesic:
M Early Broadleaf
MP Upland Pine
MB Upland Oak
MBOG Broadleaf Old Growth
HP/HB Transition Zones
A Agriculture
DB Disturbed
■ Developed
South Main Street
553
Ackley Road
Baptist Road
Newport Landing Road
NEWPORT
Newport Neck Road
Schoolhouse Road
Fortescue Road
TURKEY POINT CORNER
Turkey Point Road
Main Street
Hickman Avenue
DIVIDING CREEK
Maple Street
Hollywood Beach
Iron Branch
Oranoaken Creek
Wallens Pond
Sheepkill Pond
Weir Creek
Creek
* denotes HB

> forest type was not undertaken and the extent of domination by beech is not known. C. E. Maguire, Inc. . . . indicates that recent selective cutting . . . occurred here.

Daniel O'Connor (pers. comm.) has suggested to me that selective cutting may also have taken place in the beech forest of Bear Swamp West, and may have played a part in its etiology.

ACKNOWLEDGEMENTS

Part of the preparation of this paper was financed through grants to the Natural Lands Trust by the Fund for New Jersey, the Geraldine R. Dodge Foundation, and the Dolfinger-McMahon Foundation. I am grateful for their support. I thank Dr. A. E. Schuyler of the Academy of Natural Sciences who contributed many suggestions during the entire project, and Andrew Pitz of the Natural Lands Trust who supervised the preparation of the Glades–Bear Swamp Master Plan, for which the research reported in this paper was carried out. Meg Thayer of the Natural Lands Trust gave constant advice and skillfully prepared the vegetation map in which many of her suggestions were incorporated which improved its final appearance; Steve Kuter, also of Natural Lands Trust, helped with final revisions of the vegetation map. This research would never have been carried out at the present scale were it not for constant assistance from Daniel O'Connor, who knows the entire study area intimately and is a public advocate for its preservation. He guided me on numerous occasions, especially in Bear Swamps East and West, and he frequently called my attention to natural features deserving of study. Dale Schweitzer also contributed important information. Thanks are due Vickie Kress who painstakingly typed the plant list.

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Bartonia No. 58: 115-119, 1994

Ecological Observations of Bear Swamp, Cumberland County, New Jersey

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The objective of the present study was to determine the composition of the arborescent vegetation of Bear Swamp East and Bear Swamp West. Bear Swamp, located in Cumberland County, New Jersey, may contain the most extensive uncut forest in southern New Jersey. Bear Swamp consists of two distinct segments: Bear Swamp East (820.4 ha) and Bear Swamp West (747 ha). Bear Swamp East is located at the headwater of the Dividing Creek watershed 39° 17′ N, 75° 05′ W; Bear Swamp West is located in the Oranoakan Creek watershed 39° 17′ N, 75° 08′ W. The water table at both sites is at or above the surface of the ground for long periods of time each year with Bear Swamp West being wetter than Bear Swamp East. Bear Swamp is underlain by the Cape May and Cohansey Formations, and is bordered to the north by the Bridgeton Formations. The soils are wet and in many portions are water-covered for most of the year. The soils are acid with a pH ranging from 4.0-5.5.

An 1843 description of Bear Swamp, which applied primarily to what is known today as Bear Swamp West, stated that it was "a noted swamp of Downe t-ship [sic], Cumberland Co., near Nantucket or Newport, through which flows the Oronoken [sic] Creek. The timber upon it is chiefly oak and poplar" (Stalter and O'Connor 1984). Much later Sharp (1912) wrote, "Silent inscrutable and alien lay the swamp, and untouched by human hands . . . . I was now in the real swamp, the old uncut forest. It was a land of tree giants; huge tulip poplar and swamp white oak so old that they had become solitary, their comrades having fallen one by one; while some of them, unable to loose their grip upon the soil, which has widened and tightened through the centuries, were still standing, though long since, dead."

METHODS

The quadrat method was used to sample trees (a tree being defined as having a straight unbranched axis 6 m or more tall with a diameter at breast height of 7.6 cm or greater). Twenty five 10 × 10 m quadrats were selected in the center of Bear Swamp East while fourteen quadrats of the same size were selected to sample arborescent vegetation in the center of Bear Swamp West. Quadrats at both sites were nested in groups of 2s and 3s. Fewer plots were selected to sample trees in Bear Swamp West because this site contained fewer tree species than Bear Swamp East. Frequency (percent quadrats occupied by each species), density (average number of trees per quadrat), relative dominance (percent basal area), and importance values (the sum of the relative frequency, relative density, and relative dominance) were calculated for trees in Bear Swamp East and Bear Swamp West (Table 1).

Table 1. Density (D), relative density (RD), frequency (F), relative frequency (RF), basal area (BA), relative dominance (RDo), and importance values (IV), for trees in Bear Swamp, Cumberland County, New Jersey. Basal area values are in cm^2.

Species	D	RD	F	RF	BA	RDo	IV
Bear Swamp East							
Acer rubrum	1.48	30	88	26	12,268.7	47	103
Ilex opaca	.92	18	64	18	1,274.8	5	41
Nyssa sylvatica	.80	16	44	15	1,664.89	6	37
Magnolia virginiana	.80	16	44	15	1,537.5	6	37
Quercus michauxii	.36	7	36	10	4,228.8	16	33
Liriodendron tulipifera	.24	5	20	6	2,665.2	10	21
Fagus grandifolia	.20	4	20	6	1,011.4	4	14
Pinus serotina	.12	2	12	3	776.0	3	8
Sassafras albidum	.12	2	12	3	289.3	1	6
Liquidambar styraciflua	.04	1	4	1	287.3	1	3
Bear Swamp West							
Ilex opaca	2.64	46	86	30	3,965.9	11	87
Nyssa sylvatica	.71	13	43	15	16,723.4	45	73
Magnolia virginiana	1.0	18	64	23	3,081.0	8	49
Acer rubrum	.79	14	50	18	5,595.6	15	47
Liquidambar styraciflua	.43	8	28	10	6,055.4	16	34
Liriodendron tulipifera	.07	1	7	3	1,247.1	3	7
Fagus grandifolia	.07	1	7	3	127.7	5	

Nomenclature follows Gleason and Cronquist (1991).

The moisture tolerance of the trees at Bear Swamp was determined using a surveyor's transit and stadia pole. Three sites were selected for study at Bear Swamp East; a tangle of *Smilax rotundifolia* prevented us from conducting survey work at Bear Swamp West. The most water tolerant tree species occupies the lowest land, the land where the water table is highest relative to the surface of the ground. The elevation of the most flood tolerant individual measured of this tree species serves as a reference point at 0.00 feet in elevation. Additional individuals of this same flood tolerant species and other species were surveyed to determine their distribution along a moisture gradient.

Historical information was obtained by a search of deeds, tax records, court house records, and census information at the County Seat of Cumberland County, Bridgeton, New Jersey. More detailed historical information of Bear Swamp and the surrounding area is presented by Stalter and O'Connor (1984).

RESULTS

Acer rubrum is the dominant tree of Bear Swamp East (Table 1). It has the highest density, frequency, relative dominance and importance values. *Ilex opaca*, which rarely grows over 12 m tall, is the dominant subcanopy species and has the second highest importance value of all the arborescent species sampled at Bear Swamp East. *Ilex opaca* has the highest importance value at Bear Swamp West (Table 1) because it is the most numerous species (density of 2.64 individuals/10 × 10 m quadrat) and attains the highest frequency (86% of the quadrats). *Nyssa sylvatica* is the dominant canopy species at Bear Swamp West and has the highest relative dominance value. *Acer rubrum* and *Liquidambar styraciflua*, are associated with *Nyssa sylvatica* in the canopy. *Magnolia virginiana* ranks second in density and frequency at Bear Swamp West and is more abundant here than in Bear Swamp East. Species composition of Bear Swamp East and Bear Swamp West is similar (similarity coefficient of 0.82).

DISCUSSION

Ilex opaca, *Nyssa sylvatica*, *Magnolia virginiana*, and *Acer rubrum* occupy the lowest wettest portions of Bear Swamp. There is little variation in moisture tolerance for many species in the swamp since *Ilex opaca*, *Acer rubrum*, *Nyssa sylvatica*, *Magnolia virginiana*, *Fagus grandifolia*, and *Liquidambar styraciflua* all are distributed within an elevation range of less than 7.6 cm.

All trees in Bear Swamp can apparently tolerate flooding, although *Acer rubrum*, *Nyssa sylvatica*, *Ilex opaca*, and *Liquidambar styraciflua* have higher density, frequency, relative dominance and/or importance values than *Fagus grandifolia*, *Pinus serotina*, and *Sassafras albidum*. *Nyssa sylvatica* and *Magnolia virginiana* appear to be restricted to the wettest sites while *Acer rubrum* and *Ilex opaca* are distributed over a greater moisture gradient.

Bear Swamp East possibly contains the most extensive (ca. 83 ha) uncut forest in southern New Jersey. Within this swamp are two state record trees: *Pinus serotina* (pond pine), and *Quercus michauxii* (basket oak). Many large trees of *Liriodendron tulipifera*, *Ilex opaca*, *Acer rubrum*, *Magnolia virginiana*, *Liquidambar styraciflua*, *Nyssa sylvatica*, and *Fagus grandfolia* grow here. Bear Swamp West contains many old large trees including the state record *Magnolia virginiana*. Both Bear Swamp East and Bear Swamp West contain the rare *Phoradendron serotinum* (mistletoe), which last century was far more commonly distributed in New Jersey (Stone 1912).

Tree seedlings and saplings (a sapling being defined as a tree with a DBH less than 7.6 cm) are represented by *Ilex opaca*, *Liquidambar styraciflua*, *Acer rubrum*, and *Nyssa sylvatica*.

The most common shrubs in Bear Swamp are *Clethra alnifolia* and *Toxicodendron radicans*. Other shrubs include: *Vaccinium corymbosum*, *Rhododendron viscosum*, *Lyonia mariana*, *Itea virginica*, and *Lindera benzoin*. The most common liana is *Smilax rotundifolia*. *Smilax* festoons the shrubs and trees; portions of Bear Swamp West are all but impassible because of the profuse growth of *S. rotundifolia*.

The herbaceous stratum contains: *Panicum* spp., *Eleocharis* spp., *Peltandra virginica*, *Orontium aquaticum*, *Dulichium arundinaceum*, *Andropogon virginicus*, *A. virginicus* var. *abbreviatus*, *Utricularia fibrosa*, *U. purpurea*, *Proserpinaca palustris*, *Myriophyllum humile*, *Eupatorium album*, *E. hyssopifolium*, and *Cladium mariscoides*. Many of the aforementioned species are characteristic of areas where the water table is above the ground for most of the growing season. Ferns include *Osmunda cinnamomea*, *Athyrium filix-femina*, and *Woodwardia areolata*. *Sphagnum* is common in wet depressions.

The moisture tolerance of *Magnolia virginiana* and *Liriodendron tulipifera* at Bear Swamp differs from that reported by Gemborys and Hodgkins (1971) in southwestern Alabama. They report that, "*M. virginiana* may be similar to *Liriodendron tulipifera* with respect to tolerance for wetness." At Bear Swamp, *Liriodendron* was observed on the higher, drier islands while *Magnolia virginiana* generally occurred on sites where the water table was at or above the surface of the ground during a 10 year interval, 1974-1984, even during periods of drought.

Bear Swamp is distinctly southern in character. With the exception of *Taxodium*, species composition in Bear Swamp is similar to that of the Great Cypress Swamp or Burnt Swamp in southern Delaware and Maryland (Stalter 1981a). *Acer rubrum* was the dominant species in Burnt Swamp with *Liquidambar styraciflua, Nyssa biflora* (reported by some as *N. sylvatica* var. *biflora*), *Ilex opaca,* and *Magnolia virginiana.* All of the aforementioned species are found in Bear Swamp. Bear Swamp contains five species that are structurally important in Quaterman and Keever's (1962) southern mixed hardwood forest: *Ilex opaca, Nyssa biflora, Liquidambar styraciflua, Quercus michauxii,* and *Fagus grandifolia.*

A thorough search of the existing literature and an examination of deeds and court-house records indicated that the wettest portions of Bear Swamp have never been logged. The first piece of indirect evidence for this is a comparison of the existing vegetation in Bear Swamp today with the giant trees described by Sharp in 1912. Sharp's poetic description, even accounting for poetic license, could be used to describe portions of Bear Swamp today, since there are many trees in the swamp as large and as old as those described by Sharp 80 years ago. Large trees today include two giant tulip poplars which are almost 5 ft (1.3 m) in diameter. The state record basket oak and a 200 yr old pond pine would have been prime lumber trees had the area been logged 100 yr ago. O'Connor recorded the DBH of a dead *L. tulipifera* that was 5.94 m in circumference in 1976. This tree fell in late 1976 and had completely decomposed by 1981.

New Jersey State Forester Gordon T. Bamford described (pers. comm. 1982) the large oak trees on the property of the Perry brothers near Pennsville, New Jersey. Bamford stated, "At the time that a section was cut for New Jersey's Tercentenary Commission in 1961, these were identified as *Quercus michauxii.* As I recall the general stand was not uniformly old; at the time of our first contact in 1948 there were a number of the larger 300+ year old individuals that we assumed had been left when the area was horse-logged, prior to tractor skidding equipment." The Perry property borders rt 49, a well travelled highway in southern New Jersey. If this accessible area escaped logging, it is quite probable that a wild boggy inaccessible area such as Bear Swamp could have also escaped cutting. The boggy nature of Bear Swamp would have posed a formidable obstacle to those who wished to harvest its trees. Horses would have had a difficult time pulling even 0.5 m or 1 m DBH logs from a forest and would have had a far more difficult time with logs in Bear Swamp where a man can sink to his knees in peat and ooze.

Many of the largest trees in Bear Swamp are hollow and unsuitable for lumber. Moreover there are far more valuable lumber trees such as Atlantic white cedar (*Chamaecyparis thyoides*), oaks (*Quercus* spp.), and pine (*Pinus* spp.) growing in abundance in south Jersey. Therefore it is reasonable to believe that portions of Bear Swamp have never been logged. Bear Swamp may represent one of the last extensive areas of virgin woodland in New Jersey.

ACKNOWLEDGEMENTS

We thank the American Holly Society for funds to conduct this study, Stevens Heckscher for an unpublished list of species he identified in the swamp, N.J. State Forester Gordon Bamford for information on the age and size of oak trees on the Perry Brothers property, and Karl Anderson and Eric Lamont for reviewing the manuscript.

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Bartonia No. 58: 121-124, 1994

Juncus caesariensis Coville (New Jersey Rush) in Nova Scotia, Canada

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The first collection of *Juncus caesariensis* Cov. (New Jersey Rush, Juncaceae) in Canada was made in 1951 by E. C. Smith et al. from a bog in Gracieville, Richmond County, Cape Breton Island, Nova Scotia (45°35′N, 60°43′W). Prior to this time, *J. caesariensis* was known only from the Atlantic coastal plain of New Jersey, Maryland and Virginia (Fig. 1). The Nova Scotia collection although deposited in the E. C. Smith Herbarium of Acadia University (ACAD), remained neglected until 1988. Neither The Flora of Nova Scotia (Roland and Smith 1969) nor The Rare Vascular Plants of Nova Scotia (Maher et al. 1978) report this species for the province. From 1989–1991 three field surveys were carried out, initially to relocate the plant in the field, and subsequently to determine the range and status of this species.

Currently, *J. caesariensis* is considered globally imperilled (The Nature Conservancy 1990), a ranking based on its known occurrence in the United States.

In New Jersey, *J. caesariensis* is reported from wet, sandy, peaty substrate dominated by sphagnum. The sites are generally open to slightly shaded and are often in or near white cedar swamps (Schuyler 1990). There are 20 extant occurrences with 35 additional historical occurrences over a seven county area. In New Jersey, this species has been designated as rare (Snyder and Vivian 1981). Ware and Wieboldt (1981) summarize the habitat in Virginia as "very acidic, usually sphagnous, extremely wet, springy or seepy areas with perennially reliable flow, but without standing water." More recently, Strong and Sheridan (1991) classify the habitat of New Jersey Rush in Virginia as peat bog habitat, i.e. acidic, saturated soil with a thick overlying layer of *Sphagnum*. Virginia has 13 extant populations and two historical stations in 5 counties. The plant is considered to be endangered (Porter 1979) in this state. Until very recently, this plant was known only from one historic station in Maryland and was designated as extirpated (Reveal and Broome 1982). Strong and Sheridan (1991) discovered three new sites in 1989.

To date, New Jersey Rush has been found in 16 sites (Fig. 1, inset) in southeastern Cape Breton Island in an area extending a distance of 35 km along the coast from Gracieville (Point Michaud) northeastward to Fourchu Bay and inland as far as Loch Lomond (sites occur in both Richmond and Cape Breton Counties). Many more potential sites for this species remain to be investigated as this part of Cape Breton Island possesses extensive wetland habitat.

Data collected so far suggest that in Nova Scotia, *J. caesariensis* is limited to sphagnous edges of bogs and fens and/or throughout small bays and coves around the perimeter of bogs/fens or small boggy openings in coniferous woods. Frequently associated species include *Picea mariana, Calamagrostis pickeringii, Muhlenbergia unifolia, Carex exilis, C. michauxiana, Smilacina trifolia, Myrica gale, Alnus rugosa, Sarracenia purpurea, Aronia*

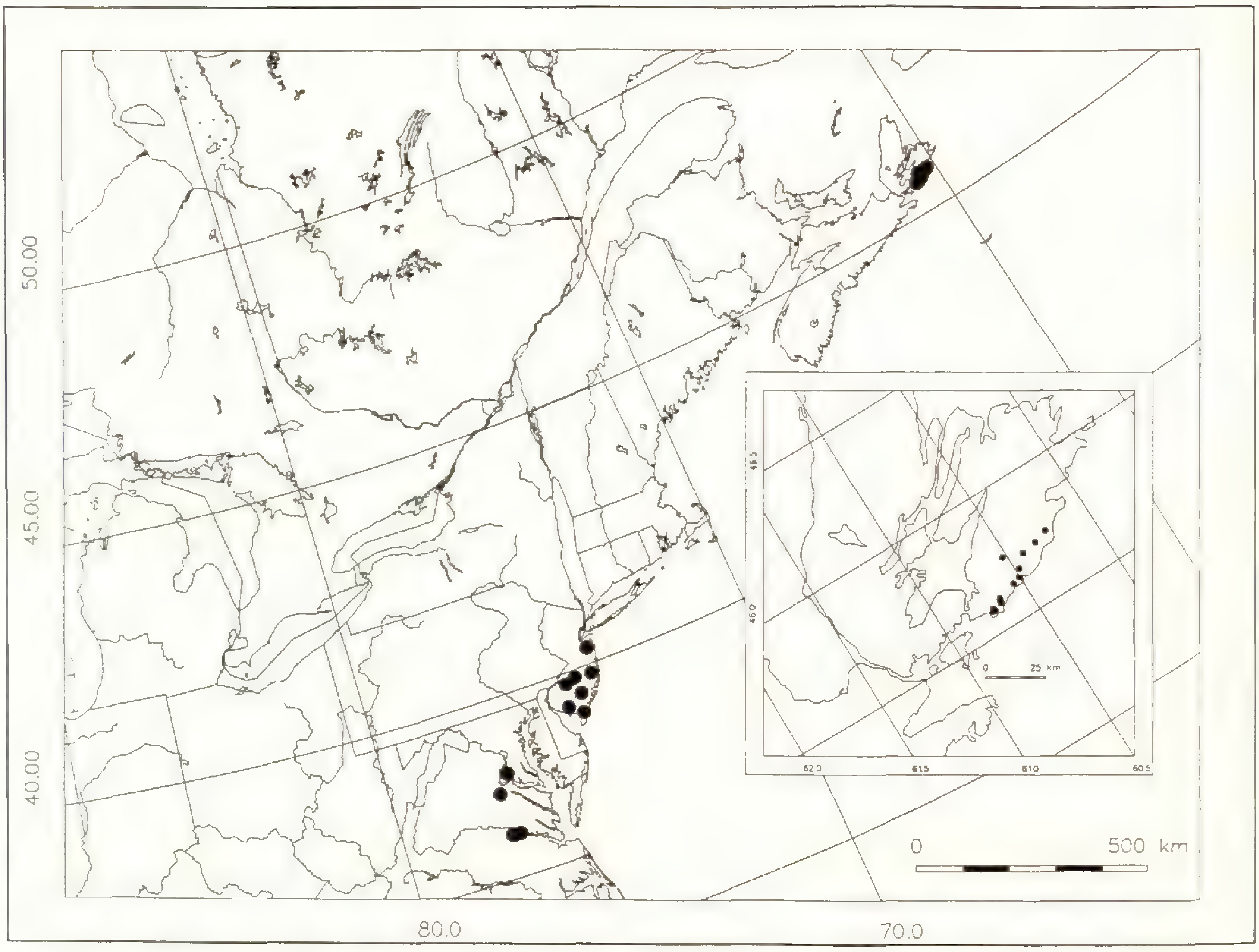

Fig. 1. World distribution of *Juncus caesariensis* (inset represents its distribution in Nova Scotia, Canada).

sp., *Rosa nitida*, *Ledum groenlandicum*, *Kalmia angustifolia*, *K. polifolia*, *Chamaedaphne calyculata*, *Solidago uliginosa* and *Aster nemoralis*. Both *Juncus canadensis* and *J. brevicaudatus* may occur with or in the vicinity of *J. caesariensis* populations. Population size estimates per site range from 3 to 1000 (individual clumps were counted).

The occurrence of New Jersey Rush along bog and fen margins immediately adjacent to the shrubs and trees of the transitional zone between wetland habitat and surrounding wooded areas suggests some shade tolerance. Clumps of New Jersey Rush were often found in animal trails which skirt the margins of bogs and fens. In several localities, plants were observed on moderately used all terrain vehicle (ATV) trails. These occurrences may indicate a tolerance to or a dependence upon some degree of disturbance.

J. caesariensis is reported to be most sensitive to circumstances affecting the hydrologic regime of its habitat (Schuyler 1990; Kral 1983; Ware and Wieboldt 1981) such as site drainage or flooding. Although New Jersey Rush occurs in a relatively undeveloped, isolated section of Nova Scotia, threats exist which could alter land drainage on two fronts. A major concern exists over the extensive logging currently being undertaken in the immediate vicinity of some populations of *J. caesariensis*. It is unknown whether this will have an impact on the hydrologic regime of adjacent new Jersey Rush wetland habitat. Future cottage development is imminent in at least the southern portion of its Nova Scotia range. This may affect *J. caesariensis* through road construction allowing landowners access to ocean frontage. Since this latter threat is likely going to threaten only a small portion of the entire range of New Jersey Rush in the province, it remains of minor concern.

The current degree of ATV activity in some portions of its range appears to be beneficial to *J. caesariensis* populations. An increase in usage of ATVs may be a potential threat to this plant.

Although potential threats to *J. caesariensis* exist in parts of its Nova Scotia range, in general the status of this plant here is relatively stable. Considering the global ranking of *J. caesariensis* however, the Cape Breton populations should be monitored on a regular basis to ensure that their status does not change. The full extent of the range of New Jersey Rush in Nova Scotia and a complete tally of the number of populations remain to be documented.

This occurrence of *J. caesariensis* is noteworthy in terms of being the first documentation of a disjunct, rare coastal plain species from Cape Breton Island. Its location makes it distinct from the well known and much studied Atlantic coastal plain flora of southwestern Nova Scotia.

The coastal plain species of southwestern Nova Scotia are believed to have migrated northward over a land bridge existing between Cape Cod and the southwestern tip of the province towards the end of the last glaciation (Keddy and Wisheu 1989). The presence of New Jersey Rush in eastern Cape Breton Island supports the theory that along with a land bridge, there was an off-shore refugium along the Atlantic coast during the Wisconsin Glaciation when sea levels were about 100 m lower than they are presently (Roland 1982). As parts of eastern Cape Breton have been noted to share some similarities of climate and habitat with the other end of the province (Roland and Smith 1969) there remains the possibility that New Jersey Rush may yet be found in southwestern Nova Scotia.

ACKNOWLEDGEMENTS

This study forms the basis of a COSEWIC Status Report prepared by the authors, with funding provided by the World Wildlife Fund, Canada. We thank the Nova Scotia Department of Natural Resources for allowing us access to their various resource materials. Erich Haber kindly generated the distribution map.

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Bartonia No. 58: 125-129, 1994

OBITUARIES

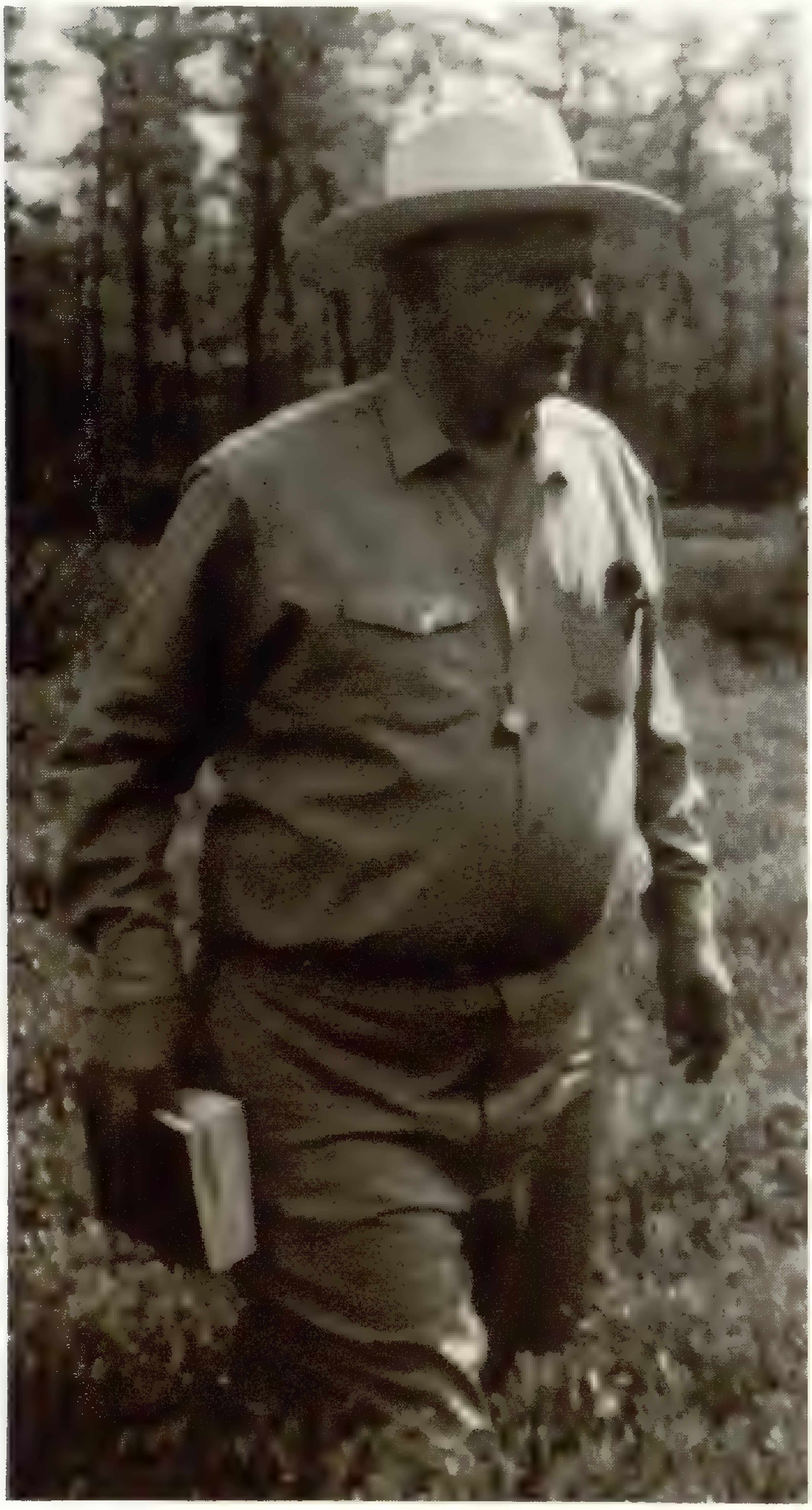
Ida Kaplan Langman (1904-1991). A member of the Philadelphia Botanical Club since 1937, Ida Langman died at Stapeley in Germantown health care center, on 10 July 1991 of cardio-pulmonary arrest after suffering from Parkinson's Disease for many years. Ida was a life member of the club and substantially contributed to its vitality. She had a deep love for botany and was generous with sharing her botanical knowledge. I remember Ida as a kind, flexible, and tolerant woman who had strong opinions and a lot of determination.

Born on 7 February 1904 in the city of Nezhin in the Ukraine, Ida came to Philadelphia as an infant a few months old. She graduated from Sharswood Elementary School, South Philadelphia High School, and Philadelphia Normal School. At the age of 18 she began her first career—35 years as a teacher assigned by the Board of Education to the Academy of Natural Sciences of Philadelphia. While working as a teacher, Ida continued her education at the University of Pennsylvania where she received her bachelor's degree in Education in 1930 and her master's degree in Botany in 1947. She married Oscar Langman in 1928, a professional violinist and photographer who died in 1987. In the 1930s, Ida did botanical field work in Monroe County, Pennsylvania, where she found *Juncus greenei* for the first time in the state. After spending the summer of 1938 in Mexico, she became fluent in Spanish and developed an interest in Mexican botany that culminated in 1964 with the publication of *A Selected Guide to the Literature on the Flowering Plants of Mexico.* Funds for preparation and travel during the 20+ years she worked on the book were provided by the National Science Foundation, American Philosophical Society, and U.S. State Department. The American Library Association selected it as the outstanding bibliography of the year. Subsequently Ida was elected a Corresponding Member of the Academia Nacional de Ciencias de Mexico, and in 1972, the Botanical Society of Mexico awarded her a medal for making a special contribution to Mexican botany. Mexican botanists named two plant species after Ida: *Lopezia langmanae* Miranda and *Stachys langmaniae* Rzedowski & Rzedowski.

In the latter 1960s Ida became the first leader of the *Index Nominum Genericorum* Project at the Smithsonian Institution where her work was praised for scholarly excellence. In the 1970s Ida worked as a bibliographer and visited European libraries for the Hunt Institute for Botanical Documentation of Carnegie-Mellon University where her reliable performance was praiseworthy.

Ida published about 50 articles in magazines and journals in addition to her book. She also was an active member in the Women's International League for Peace and Freedom, the Philadelphia Teachers Union and the American Civil Liberties Union.

Survivors include a brother, Frank E. Kaplan, M.D., of Doylestown PA, a sister, Mae K. Millstone of York PA, five nephews, and two nieces. ALFRED E. SCHUYLER.



Arthur Cronquist (1919–1992). There was never a dull moment when travelling with Art Cronquist. If we weren't talking botany, he would be telling jokes or singing; he could handle both difficult pieces and plain doggerel with ease. At a restaurant he would carefully study the menu and then order a hamburger, plain, and water, "lots of water, bring a pitcher." He loved to meet people and converse.

He had written profusely, and his writings profoundly affected the course of botanical thought. He wrote and spoke with authority, as evident in his evolution and classification book: "The book presents taxonomy as seen by Cronquist . . . I make no pretense of equal time for opposing views. For other points of view, read other authors" (Cronquist 1988).

Arthur Cronquist was born on 19 March 1919 in San Jose, California. His parents divorced when he was 4 years old, and he was raised by his mother whose maiden name he kept for his own. As a teenager he collected plants in Utah and Idaho, and discovered several State records which led to his first scientific publication in 1939: "New plant records in Utah and Idaho" (Cronquist 1939).

Art began his undergraduate studies at Idaho State University and majored in range-management. His first field botany course was taught by the late Dr. Ray J. Davis. One of the course requirements was the preparation of a plant collection. Dr. Davis chose the two top students to study the two largest families: the Poaceae and the Asteraceae. To determine who would be assigned each family the two students flipped a coin and Art got the comps. He would eventually become a world authority on the family, and among his many publications was the Asteraceae treatment in Ray J. Davis' *Flora of Idaho* (Cronquist 1952).

In 1938, at the age of 19, Art earned his B.S. degree from Utah State University where he was influenced by the late Dr. Bassett Maguire—Art's professed "professional father."

In 1940 Art married Mabel Allred, and during that same year he received his M.S. degree from Utah State; his master's thesis was a taxonomic revision of a group of asters (Cronquist 1943). A childhood injury left Art ineligible for military service during World War II; thus, in the early 1940s he worked on his Ph.D. at the University of Minnesota. His major professor was Dr. Carl O. Rosendahl, a former student of the German botanist Adolf Engler. Rosendahl and Cronquist would later co-author "The goldenrods of Minnesota" (1945) and "The asters of Minnesota" (1949).

In 1943, while still working on his doctorate, Art accepted a position at the New York Botanical Garden. For one year he worked half-time on the tropical families Simaroubaceae and Sapotaceae, and half-time on his dissertation, "Revision of the North American species of *Erigeron*, north of Mexico" (Cronquist 1947). After defending his doctoral dissertation in 1944, Art continued working another two years at the New York Botanical Garden. However, he did not want to pursue a career in neotropical botany; thus, in 1946 he accepted the position of Assistant Professor of botany at the University of Georgia.

Arthur Cronquist excelled at teaching. He maintained affiliation with academic institutions throughout his career (Washington State University: Assistant Professor, 1948–1951, and Research Associate, 1953–1966; Columbia University: Adjunct Professor, 1964–1992; City University of New York: Adjunct Professor, 1968–1992), and he wrote two college textbooks on general botany: *Introductory Botany* (1961) and *Basic Botany* (1973). Both books went through two editions and both appeared in Spanish, while *Introductory Botany* also appeared in Italian. Many of his botany courses were field-oriented, and some of his "field trips" covered over 5,000 miles by vehicle in three weeks time. His door was always open to students (and anyone else), and he never hesitated to assist students in the field. As my major professor, he and I traveled to Utah, Canada, New England, and the southern Appalachian Mountains, largely in pursuit of eupatoriums but any plant was fair game. I probably learned more botany in his pick-up truck than in any graduate level course. When I discovered a new species of *Eupatorium* I assumed that my major professor would co-author the diagnostic publication; but no, Art declined authorship and as a result I learned-by-doing and grew as a botanist.

After teaching two years at Georgia, he accepted the position of Assistant Professor at Washington State University. In 1951 he spent a year in Brussels, with his wife and two children, working on the flora of the Belgian Congo for the national government of Belgium. Then, after an absence of five years, Art returned to the New York Botanical Garden where he remained for the next 40 years.

Arthur Cronquist probably contributed more to an understanding of the flora of temperate North America than any other 20th century botanist. He authored or co-authored many of the region's major floristic works, including *Vascular Plants of the Pacific Northwest* (1955–1969), *Manual of Vascular Plants of Northeastern United States and Adjacent Canada* (1963, 1991), the Asteraceae for *Vascular Flora of the Southeastern United States* (1980), and *Flora of the Intermountain Region* (1972–present). He was also involved in varying degrees in the preparation of many other major floristic works.

Early in his career Art began studying the problems associated with the concept of a plant species. He was critical of the strictly reproductive species-concept, and formalized a species-concept under which most plant taxonomists now work: "Species are the smallest groups that are consistently and persistently distinct, and distinguishable by ordinary means" (Cronquist 1978). The practical application of this concept was not always initially popular with others. In 1945, while preparing a treatment of the Asteraceae for the *New Britton &*

Brown Illustrated Flora (at the age of 26), Art published a paper on the genus *Antennaria* in the journal *Rhodora*. At the time, over 30 species of *Antennaria* were generally recognized from the northeastern states and adjacent Canada. Art recognized three species and six additional infraspecific taxa (Cronquist 1945). Art's treatment of the genus brought a quick and biting response from Dr. Merritt Lyndon Fernald: "It is, then, at least surprising to be told by one who blew in from the West so recently . . . that in all this diverse area we have only three fairly well-marked species . . . . If his [Cronquist] treatment of *Antennaria* is typical of what is to be expected for other groups in the new Illustrated Flora, it would seem that that work will be an abbreviated pocket-novel . . . " (Fernald 1945). But Art was undaunted by Fernald's harsh review; throughout his career Art reserved a special passion for taxonomically difficult and complex groups of flowering plants. When I asked him about his treatment on the stemless blue violets (Gleason and Cronquist 1991), he replied: "If I can't tell the plants apart, I can't expect someone else to." His taxonomic conclusions were always based on extensive field, herbarium, and library study.

The general system of classification of flowering plants was in a moribund condition when Art published his early taxonomic works. The popular but archaic system of Engler and Prantl no longer reflected current evolutionary thought. In the 1950s Art began publishing his thoughts on a new system of angiosperm classification (Cronquist 1957, 1960, 1963, 1964, 1965). These thoughts culminated in three books on evolution and classification (Cronquist 1968, 1981, 1988), including his magnum opus, *An Integrated System of Classification of Flowering Plants*, currently one of the most widely used systems of classification in North America, Australia, and China.

At a memorial service held at the New York Botanical Garden on 5 May 1992, Dr. Peter Raven compared the botanical achievements of Arthur Cronquist with those of Carl Linnaeus. Several other outstanding botanists of our day have likened him to Asa Gray. It was a great privilege to have had Arthur Cronquist as a friend and mentor. He will be sorely missed by all who knew him.

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ERIC E. LAMONT

Thomas J. Day (21 March 1938-2 July 1992). Of Mahanoy City, Pennsylvania, and a long-time member of the Philadelphia Botanical Club, Tom had a great interest in botany from his days as a Boy Scout. He spent many hours in local woodlands studying the flora and kept extensive records of the plants he found. He was an avid hunter and fisherman as well as gardener and amateur cook. Tom also assembled a large library of books on plants and gardening. He attended the Pennsylvania State University and Lehigh Community College, and was pursuing the bachelor of science degree at the time of his death. He is survived by his wife Betsy and his son Daniel. ELIZABETH B. FARLEY

Bartonia No. 58: 130-137, 1994

REVIEWS

Manual of Vascular Plants of Northeastern United States and Adjacent Canada, 2nd ed. by Henry A. Gleason and Arthur Cronquist. New York Botanical Garden, Bronx. 1991. lxxv + 910 pp. $74.60 incl. shipping (cloth).

The Gleason and Cronquist manual has returned looking very similar in appearance to the first edition. However, upon closer inspection the reader will notice that the manual has changed considerably.

Changes are noted upon first opening the book. The front endpapers provide a map indicating the region covered. With the senior author, Henry Gleason, having died in 1975, Cronquist in the preface now takes full responsibility for the entire contents of the manual (p. v).

The glossary is now much more complete with 967 entries, 378 of which are new. Cronquist has done an excellent job providing succinct, accurate definitions that are understandable to all. The glossary now includes many terms used but not defined in the first edition, such as *cuneate, ray, spikelet,* and *style.* However, some terms defined in the first edition are no longer defined in the new edition. Students would have been better served if *basal, rhizophore, seed,* and *stem* had been retained in the glossary.

The general keys that follow the glossary are superb. Out of all the manuals I have used, I have found the general keys in the Gleason and Cronquist manual to be the easiest to use. The general keys are now strictly dichotomous, and this adds to their simplicity and ease of use. There has been some realignment of the general sections, which now total eighteen. However, a couple of things in the general keys may cause confusion for the beginning botanist. In section 10, in referring to the perianth, the term *cycle* is used while in section 11 the term *circle* is used. The term *cryptogam* is used, although in a current standard botany text (Raven et al. 1992) this term is referred to as "archaic."

New to this edition are the synoptical keys to the angiosperms which precede the general keys. These keys are limited to the angiosperms, the taxa addressed in Cronquist's Integrated System (which the manual is now arranged on). They will certainly prove helpful to taxonomy instructors in teaching the natural order of the angiosperms. However, there is a problem with the type size used in the synoptical key headings. The heading of the key to the subclasses of Magnoliopsida is in large type, followed by keys for orders and families of each subclass in smaller type. The subsequent key to the subclasses, orders, and families of Liliopsida is also headed in the smaller size type. This gives the misleading impression that the synopses deal only with the Magnoliopsida.

The text follows the same format as edition one, but there are plenty of taxonomic changes. *Breweria* is now *Stylisma. Psilocarya* and *Dichromena* are now in *Rhynchospora. Manisuris* is now *Coelorachis.* Some species of local interest have been lost not to bulldozers but to lumping. These include: *Panicum hirstii, Rhynchospora microcephala, Scleria nitida,* and *Scirpus ancistrochaetus.*

The nomenclatural nightmare that exists in *Xyris* could have been better dealt with in the manual. *Xyris flexuosa* of the first edition is now *Xyris caroliniana* in the new edition. *Xyris caroliniana* of the first edition is now *Xyris difformis* in part and *Xyris jupicai* in part. In the new edition, Cronquist mentioned *X. flexuosa* in synonymy under *X. caroliniana* but failed to mention the misapplication of the former *X. caroliniana* under *X. difformis* and *X. jupicai*. This could give the misleading impression that *X. flexuosa* merely has been lumped into the *X. caroliniana* of the first edition.

Sure to create controversy are the new treatments for *Dichanthelium* and the stemless blue violets. For *Dichanthelium*, Cronquist claimed to have "drawn heavily" (p. v) from Gould and Clark (1978). However, Gould and Clark recognized only 22 species for the manual's range and treated *Dichanthelium* as a genus, while Cronquist recognized 32 species and kept *Dichanthelium* at the subgeneric level under *Panicum*. The most striking example of lumping in this new treatment occurs with *P. dichotomum*, which now includes *P. annulum*, *P. lucidum*, *P. mattamuskeetense*, *P. nitidum*, and *P. roanokense* of the first edition. For the stemless blue violets, Cronquist as drawn on his "own observations in the field over several decades" (p. v). Apparently his viewpoints over the past three decades have changed drastically: in the new edition only 6 species are recognized compared to 24 in the first edition. Most of the formerly recognized species have fallen into synonymy under either *Viola sororia* or *V. palmata*, making these two species so broad that they are as difficult to comprehend as the numerous cryptic species recognized in the first edition. For both *Dicanthelium* and *Viola* the reader is given very little evidence to substantiate this radical changes.

The distributional information is significantly improved from the first edition, but there are still more errors than I would like to see. Maine is listed in the range of *Monotropsis odorata*, although it should be Maryland. *Andropogon ternarius*, *Listera smallii*, *Salix serrisima*, *Utricularia inflata*, and *Xyris caroliniana* all have been recorded from New Jersey, but the manual does not include New Jersey in their ranges. *Utricularia olivacea* is not included in the manual although it occurs in New Jersey. The manual has *Helonias bullata* formerly occurring in New Jersey, yet New Jersey has more extant populations of *Helonias* than any other state in the plant's range. Information on the distribution of weeds could have also used some updating. Describing *Microstegium vimineum* as only "sparingly introduced" and *Bidens polylepis* as only "occasionally adventive eastward" may have been accurate in the 1960s but it certainly is not now.

The index suffers from numerous typographical errors and errors of omission. Recognized names for plants established in the range are listed in Roman type with all other names in italic type. However, I have noticed numerous instances where the wrong type was used for a taxon. Several synonyms used in the text are omitted in the index. The recognized taxa *Mollugo*, *Saxifraga rivularis*, and *Scirpus pungens* are also omitted. Species for *Carya*, *Cuscuta*, *Hedyotis*, *Linum*, *Myriophyllum*, and *Sparganium* are not indexed even though 10 or more species are recognized for each genus. The reader is also referred to the wrong page for *Amianthium*, *Corema*, ironweed, Jerusalem-artichoke, and *Melampyrum*.

Lastly, this new edition, like the first edition, fails in not providing a summary of the number of families, genera, and species established in the range. Willing to wait no longer, I have counted them as follows: 192 families, 1080 genera, and 4271 species.

I recommend this book to any field botanist, botany student, or taxonomist working near or in the range of the manual. Despite the criticisms, it is the only recent manual for the northeastern US available. Cronquist did us all a great service by getting this published before his unfortunate death on 22 March 1992.

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GERRY MOORE

New Jersey Ferns and Fern-Allies, by J. D. Montgomery and D. E. Fairbrothers. Rutgers Press, New Brunswick. 1993. 300 pp., 100 maps, and 125+ line drawings. $45.00.

For those who are fortunate to own a copy, or who have access to a library copy of Chrysler and Edwards' 1947 Ferns of New Jersey (a very rare book, with supposedly only 700 copies printed, most of which went to libraries and colleagues and friends of the authors), the eagerly awaited new New Jersey fern book, by Montgomery and Fairbrothers, is a little like running into an old friend who has undergone a face lift. But unlike some face lifts or revisions that obliterate, muddle, and deface, this one not only preserves much of what worked in the 1947 fern book, but invigorates their book with the 46 years of additional taxonomic research and distribution data that had passed-by and outdated much of the Chrysler and Edwards book. This revision is much more than cosmetic, and everything in this book, from text to maps to illustrations, has been rethought, rewritten, and revised. The result is a concise, competent, and readable treatment, which makes this book the new standard on the distribution, diversity, and identification of New Jersey ferns and fern-allies.

One of the strong points of the Chrysler and Edwards book, was its format, which this book largely adopts. This first five sections—Historical Introduction, Fern Structure and Classification, Hybrids, keys, Ecology and Distribution—are similar in scope to those of the 1947 book. However, all these sections have been greatly expanded and contain much more information. The Historical Introduction is particularly well done; being both informative and entertaining, it nicely sets the context. For the new student of pteridophytes, the section on Fern Structure and Classification is very helpful. In it, the technical terms used in the book are introduced, clearly defined, and illustrated. And for those whose knowledge of New Jersey is limited to car window views from the state's major highways, the section Ecology and Distribution provides an excellent overview of New Jersey's geology, geography, and generalized habitats. The listing of references is extensive and is almost worth the price of the book alone.

A single page per taxon is used to describe each species or subspecific taxon. For each, its latin name, major synonyms, and common name(s) head the page. This is followed by brief notes on description, habitat, general distribution, distribution in New Jersey, and general comments. The arrangement is fern-allies first, true ferns second, with the genera grouped by family. The facing page is devoted to a distribution map and line drawings of the taxon. Nearly all taxa discussed are illustrated and their distribution within New Jersey mapped. This is also the format of the 1947 book, although not quite as assiduously adhered to. The new fern book's dimensions are virtually identical to the old fern book, and at 23.5 cm × 16 cm, it can be conveniently carried into the field.

A tremendous amount of new information is presented in the new book. For example, Chrysler and Edwards recognized 8 families, 29 genera, 78 species, 16 subspecific taxa, and 16 hybrids, while Montgomery and Fairbrothers now recognize 15 families, 30 genera, 80 species, 10 subspecific taxa, and 32 hybrids as occurring in New Jersey. A total of 118 taxa (by my tally, not the authors' 114 on p. 25) are included in the checklist—a remarkable diversity for such a small, and densely populated state. Even more remarkable is the statement on page 41, that 94 taxa of ferns and fern-allies have been documented from Sussex County, nearly one quarter of total taxa reported from the continental United States. The distribution maps are based on collection localities that are vouchered by herbarium specimens and are plotted on a county outline map of the state. Three different sized dots are used to indicate the relative age of the collections. An oversight of the book is that herbaria examined are not acknowledged. According to Montgomery (pers. comm.) the following collections were examined: Chrysler Herbarium, Rutgers University, New York Botanical Garden, Academy of Natural Sciences of Philadelphia, and the Smithsonian Institution were checked for records of all taxa, with selected genera or taxa examined at Berlin, British Museum, Drew University, University of Michigan, Montclair State University, Newark Museum, Rutgers-Camden, Staten Island Museum, and Upsala College.

The book does contain some omissions, errors, inconsistencies, and other problems. My greatest criticism is the generally poor layout and reproduction of the illustrations. This is a shame, because the line drawings greatly enhance the usefulness of the book, and, as an aid in identification, frequently surpass the black and white photographs used in the 1947 book. However, may of the illustrations are too small, and the details are often difficult, or in the case of some species of *Equisetum*, nearly impossible to discern. No scale is provided for the size of the reproductions, and there is no consistency of scale between illustrations or even within genera. There is a lot of unused, blank space in the book that could have been better used by filling them with full page illustrations. The distribution maps could have then been placed as insets within non-critical areas of the illustrations, or better yet, moved to the text page. The distribution maps also suffer from being reproduced a little too small, and, as a result, the smallest sized dots are sometimes obscured by county lines or county names. Going to a slightly larger format may have solved the problem.

Some other comments, more or less from the front to back, are as follows. The keys are awkwardly placed between the sections Hybrids and Ecology and Distribution, rather than immediately preceding the section describing the taxa or the very beginning of the book where they would have been a little more convenient to use. Table 2 on page 41 lists *Lycopodium inundatum* as being restricted to the Ridge and Valley and Highlands Provinces, whereas the distribution map (p. 73) for this species accurately shows occurrences in four Coastal Plain counties. The illustrations for *Ophioglossum pusillum* and *O. vulgatum* (pp. 143 and 145) are reversed. The second sentence under comments on page 144 should read "having no known *extant* occurrence." The Appalachian gametophyte (*Trichomanes* sp., p. 168) is neither keyed nor illustrated. Granted, a working key to it is probably hopeless without including look-alike algae and mosses. An illustration, however, would have greatly facilitated identification, since it is probable that only a handful of the book's readers have ever seen this most obscure of all of New Jersey's ferns. After publication of this book, it was described as a new species, *Trichomanes intricatum* Farrar (for a detailed description, illustration, and distribution see Farrar 1992). The index is inconsistent in its inclusion of people, places, and subjects. For example, St. Patrick (p. 1), Quaker Bridge (p. 152), and snow (p. 35), are in, but Napoleon (p. 232), Blairstown (p. 194), and condoms (p. 56), are not.

Non-native taxa like the introduced (and presumably planted) *Marsilea quadrifolia* (p. 274) and the adventive *Azolla caroliniana* (p. 276) are keyed, described, illustrated, and included in the checklist (p. 278), while *Phyllitis scolopendrium*, another established introduction, is not, and is only briefly discussed under *Asplenium rhizophyllum* on page 192. Adding this species to the checklist would then bring the total of taxa of New Jersey ferns to 119. It should be noted that there are additional taxa covered in the book that are not included in the checklist or tallies. Some, like *Polypodium appalachianum* (p. 170), *Asplenium trichomanes* subsp. *quadrivalens* (p. 198), and *Osmunda cinnamomea* var. *glandulosum* (p. 147) are generally accepted as valid taxa, while others like the three varieties of *Botrychium simplex* (p. 134) are no longer considered as taxonomically significant. So at least 122 taxonomically valid taxa of New Jersey ferns and fern-allies are discussed in this book—eight more than the 114 advertised.

I suppose that like any face lift, a certain amount of blemishes and wrinkles are bound to be missed. Fortunately for the users of this new fern book, the imperfections are mostly minor, and do not seriously detract from the value and usefulness of the book. As a revision, it is an improvement over the old, and solidly advances our knowledge of New Jersey's ferns. I give it two fronds up.

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CHRYSLER, M. A. AND J. L. EDWARDS. 1947. The Ferns of New Jersey. Rutgers University Press, New Brunswick.

FARRAR, D. R. 1992. *Trichomanes intricatum*: The independent *Trichomanes* gametophyte in the eastern United States. Amer. Fern J. 82: 68-74.

DAVID B. SNYDER

British Plant Communities. Volume 1. Woodlands and Scrub, edited by J. S. Rodwell. Cambridge University Press, New York. 1991. x + 395 pp. $160.00 (cloth).

This book is the first in a five-volume series that will provide a comprehensive, uniform description of the vegetation of Great Britain and adjacent islands, excluding Ireland. Volume 1 begins with the history of the project and the methods of collecting, analyzing, and presenting the data. This general introduction is followed by an overview of the edaphic, climatic, and successional relationships of the five major groups of woodland and scrub community types: "mixed deciduous oak-birch woodlands," "beech and yew woodlands," "pine and juniper woodlands and montane willow scrub," "wet woodlands with alder, birch and willows," and "scrub and underscrub communities." The overview concludes with a key that distinguishes the community types and sub-types and describes their intergradation and regional variation. The categories are based on physiognomy and floristics and are named after one to three of the most frequent species—for example "*Quercus petraea-Betula pubescens-Dicranum* woodland," "*Salix lapponum-Luzula sylvatica* scrub," "*Holcus lanatus* sub-community."

Most of the volume consists of detailed accounts of each of the 25 community types. The treatments all follow the same format, beginning with a list of synonyms for the community type plus lists of its constant species and rare species. Next come descriptions of physiognomy, sub-communities, habitat (including edaphic, climatic, biotic, and human factors), zonation and succession, distribution in Great Britain, and affinities (i.e. correlations with European phytosociological literature and distinctions from related community types). The descriptions are followed by a floristic table with a species list of vascular plants, bryophytes, and lichens; plus columns representing their presence in the respective sub-community types and the community type as a whole. The species are grouped according to stratum, frequency, and sub-community. Each species in each column is given a frequency value for the percentage of stands in which it occurs, and a range of abundance according to the Domin scale of cover classes. The table concludes by summarizing the altitude, slope, and species richness of the samples; and height and percent cover of their four strata (tree, shrub, herb, and ground). Each accounting concludes with outline maps of Great Britain containing dots for the community locations according to a grid system of 10 km × 10 km. The final sections of the book are an index to synonyms of the community types, an index to species, and a bibliography.

This series will be valuable to botanists and ecologists of northeastern North America. Features of the methodology could be applied here, and the floras of this region and northwestern Europe have many species in common. The series is appealing because of the detail and integration of its content; the informational classification of community types (in contrast to Braun-Blanquet nomenclature); the consistent use of scientific binomials; the abundance of charts, tables, diagrams, and maps; and the lucid style of writing. The printing and binding are of good quality. Besides the volume reviewed here, two of the other volumes in this series are now available (at $195.00 each): Volume 2, Mires and Heaths (1991); and Volume 3, Grasslands and Montane Communities (1992). Despite its high cost, the entire series should be acquired by libraries of universities with programs in botany or ecology. LARRY H. KLOTZ

Easter Island Earth Island, by P. Bahn and J. Flenley. Thames and Hudson Inc., New York. 1992. 240 pp., fully illustrated with maps and photographs. $24.95.

The remoteness of Easter Island perhaps is best appreciated from aboard a jet airliner as it begins its descent and starts its approach to the only landing strip available for thousands of kilometers. Santiago, Chile, more than 3,750 km to the east, is some five hours away. The nearest airport west of Easter Island is in Papeete, Tahiti, and is over 4,000 km and six hours away. You pray that nothing goes wrong, and that the wheels find the tarmac, and not the turbulent waters of the Pacific Ocean, which have been pounding and slowly eroding the cliff-lined shores of this volcanic mote for its three million years of existence above the sea. The plane, of course, is guided by twentieth century technology, but the small band of polynesians that set sail from eastern Polynesia sometime in the first centuries AD, reached Easter Island by using a combination of navigational skills developed over thousands of years of colonization of the islands and atolls of Polynesia, as well as an extraordinary bit of good luck.

Where these voyagers came from, why they came, the geology, climate, flora and fauna of the island they settled, how they existed, how they carved, transported, and erected the massive, monolithic moai (statues), European discovery of the island, and remarkable new insight into the probable causes of the warfare and violence that ultimately brought the near extinction of one of the world's most remarkable prehistoric cultures, are explored in *Easter Island Earth Island*. By using the most recent archaeological, ethnological, linguistic, physical anthropology, and botanical data to support their theories, the authors minimize the use of conjecture and speculation, which has been a common failing of many other popular books on Easter Island.

Through the years the debate over the origin of the people of Easter Island has been the subject of much controversy. Some, like Erich Von Daniken's theory that explained all the mysteries of Easter Island through the intervention of benevolent ancient astronauts, can be dismissed without need for further comment. Other theories, although equally implausible, have gained general acceptance from the lay public. Number one among these is Norwegian explorer Thor Heyerdahl's theory that Easter Island was first settled by Amerindians sailing from Peru. Heyerdahl's books promoting a South American origin for the culture of Easter Island have been so popular, that the authors devote much space to countering many of Heyerdahl's arguments. For example, Heyerdahl has claimed that the totora (*Schoenoplectus californicus*, but identified as *Scirpus riparius* in the book) used by the Peruvians to build their reed sailing boats is identical with the Easter Island plant now growing on the shores of the fresh water lakes in the calderas of the island's volcanoes and, since the major method of reproduction is by rhizomes, the species clearly had to be transported by humans to the island. The authors counter this argument by stating that the variety of this species now growing on Easter Island is distinct from varieties occurring in Peru and, since the species obviously reproduces from seeds, totora could have easily been transported to the island by birds, noting that Darwin washed the seeds of 52 plants from the feet of water birds. Recent pollen analysis has shown that totora has been present on Easter Island for at least 30,000 years, so dispersal by humans, regardless of which way they sailed, is no longer tenable. Like floating ducks at a carnival shooting gallery, Heyerdahl's arguments are shot down one by one, leading the authors to conclude, "Heyerdahl's theory of a South American source for Easter Island culture is indeed a tottering edifice precariously based on preconceptions, extreme subjectivity, distortions and very little hard evidence. In putting it together over the years, he has come to resemble someone who has painted himself into a corner with no means of escape, but is loath to admit it."

For readers not particularly interested or amused by academic shenanigans, the overriding issue presented in *Easter Island Earth Island* is an ecological one, centering on the dangers of over-exploitation of limited natural resources and the globally relevant consequences of that action. We are all familiar with the "canary in the coal mine" analogy used to generate support for the preservation of species, fragile ecosystems, and overall biological diversity. Or the one that compares the loss of endangered species to the loss of bits and pieces of a jet airliner. Although still frequently invoked by defenders of diversity, both of these analogies are really a couple of old chestnuts, and are about as viable as the American species of that tree. Even if we lost every rare and endangered plant species currently extant in New Jersey, it would be unlikely that this would be enough to set into motion a domino effect that would ultimately unravel any given ecosystem, let alone bring about the collapse of civilization. Our flora, and the ecosystems they are dependent on, are too diverse and resilient to be taken down by the loss of such a relatively minor portion of the overall biomass. However, if this scenario were to be played out on a different stage, one where biological diversity is depauperate, where critical links between species and ecosystem are real, where equilibrium between the two are tenuous at best, the loss of even a few species could be enough to tip the balance. This is apparently what happened on Easter Island.

The story of Easter Island is, as the authors conclude, a cautionary tale that carries two timely warnings. The first is that without wise management, all natural resources are finite. Despite the obviousness of the statement, it is a warning that remains largely unheeded by most people on our planet. The second warning comes in the form of a lesson. In the author's words, "Easter Island is small, and its ecosystem relatively simple. It has limited topography, a rather stable climate, a limited range of rocks, soils, plants, and animals. Whatever one did to alter that ecosystem, the results were reasonably predictable. One could stand on the summit and see almost every point on the island. *The person who felled the last tree could see that it was the last tree. But he (or she) still felled it.* This is what is so worrying. Humankind's covetousness is boundless. Its selfishness appears to be genetically inborn. Selfishness leads to survival. Altruism leads to death. The selfish gene wins. But in a limited ecosystem, selfishness leads to increasing population imbalance, population crash, and ultimately extinction."

With this new insight, many of the old riddles and mysteries of Easter Island no longer seem to be quite so compelling. From this the most isolated inhabited flyspeck of geography, a new mystery is born, global in its reach: Will humankind learn the lesson of Easter Island? DAVID B. SNYDER

Bartonia No. 58: 138-140, 1994

NEWS AND NOTES

SUPPLEMENT TO *NEW JERSEY WILD PLANTS.* This 1992 supplement corrects the nomenclature to that used in the 1991 second edition of Gleason and Cronquist's *Manual of Vascular Plants of Northeastern United States and Adjacent Canada.* This supplement, plus a 1989 list of species reported since the book was published in 1983, and some corrections, will be sent postpaid for $1.00 to anyone wishing the information. Order from Mary Y. Hough, #1, Route 94, Blairstown, NJ 07825. The book is also still available for $14.95 postpaid from the same address, and would include the supplements. MARY Y. HOUGH

1991 AND 1992 NEW CASTLE COUNTY, DELAWARE, RARE PLANT SURVEY HIGHLIGHTS. The 1991 botanical field season proved, as in earlier years, to be both interesting and exciting for us in the way of new discoveries and old locations of both historical and extant species in the state. Beginning in the Brandywine drainage, some notable finds included the second DE population of *Smilax hispida*, formerly known only from the Mt. Cuba area, a third DE station for *Carex davisii*, several new populations of *Panax quinquefolius*, *Aster prenanthoides* (a former SH species), and the second DE population of *Heliopsis helianthoides* on the PA/DE state line. A major change was the discovery, partly through a discussion with fern expert Donnell Redman, and confirmed in the field, was that our DE population of *Cystopteris bulbifera* was actually *C. tennesseensis.* The most exciting find in the drainage, though, and perhaps of the field season, was the confirmation of the existence of a small population of *Asplenium trichomanes*, which had been ranked SX and had not been seen in the state in nearly 90 years. Its current presence had first been noted in a Delaware Nature Society publication. Near this fern also grew populations of other rare species, including *Hybanthus concolor*, *Poa sylvestris*, *Conopholis americana*, and *Cystopteris protrusa*, many growing on rich wooded slopes dominated by an enormous population of naturalized *Trillium grandiflorum.*

The Red Clay valley did not yield quite as exciting finds as the Brandywine drainage, but still produced a number of surprises, the best being a single plant of *Aster laevis* (former SH) found growing on a serpentine roadcut. Other interesting sightings included a small population of *Caltha palustris*, two colonies of *Amianthium muscaetoxicum*, *Eupatorium sessilifolium*, *Ostrya virginiana*, and *Dryopteris celsa*, the last in a roadside seep. Discoveries in the other Piedmont drainages included a small colony of *Poa autumnalis* in the Middle Run valley, *Lilium canadense* in the White Clay, and the state's largest current population of *Lobelia spicata* in the Mill Creek drainage along with a small but dense colony of *Scleria pauciflora* at its second DE station.

On the upper coastal plain and Fall Line region of New Castle County, including Iron and Chestnut hills, occurred a mix of Piedmont and Coastal Plain rarities. Chestnut Hill yielded *Botrychium matricariaefolium* and *Ophioglossum pycnostichum*, while *Liparis lilifolia* was found on Iron Hill. A roadside and young woods near the latter's base yielded *Angelica venenosa* at its first confirmed recent sighting, along with *Carex lanuginosa*, more *Ophioglossum pycnostichum*, and a single male plant of *Thalictrum revolutum*, a new DE record. Lastly, a small population of the elusive *Aster radula* was found near a tributary of the Christina River.

Farther south, our explorations in one of the Blackbird State Forest tracts yielded

Lespedeza hirta, *Agrimonia rostellata* (former SH), *Kalmia angustifolia*, and *Eupatorium sessilifolium*, among more than a dozen DE rarities. *Clitoria mariana* was also discovered near another Blackbird Forest tract. Several localities for the rather local *Lysimachia hybrida* were discovered in the Smyrna River and Cypress Creek drainages. *Apocynum androsaemifolium*, which we expected more likely to be found in the Piedmont, actually turned up in great abundance along a disturbed roadside and in a powerline cut, the latter population growing with or near a number of leguminous rarities such as *Desmodium marilandicum*, *laevigatum*, and *viridiflorum* and *Lespedeza hirta* as well as *Gentiana saponaria*. A small population of *Hypericum gymnanthum* turned up in a recently sprayed powerline cut, along with *Aletris farinosa* in great abundance. Finally, near the end of the season, exploration of a powerline cut along the Maryland border yielded a large population of *Cacalia atriplicifolia* well away from its more Piedmont haunts along with the previous SH species *Lechea villosa*.

In 1992 on the Piedmont, finds in the Brandywine drainage included the second DE population for *Corallorhiza odontorhiza*, another station for *Lobelia spicata*, and two new stations for *Scirpus pendulus*. The Red Clay produced *Aplectrum hyemale* (on the PA/DE state line), *Asclepias exaltata* blooming along a much-traveled roadside, and two stations for *Lilium canadense*. Further exploration of the serpentine outcrops near Hoopes Reservoir with Bill McAvoy led to a second DE station for *Carex bushii*, and on the closely mown grounds of an estate, more *Cerastium arvense* var. *villosum* in a population extension of a previously known roadbank station along with a colony of *Senecio anonymus*, previously thought extirpated in the state. Along a Piedmont roadside passed frequently by botanists, we found *Chamaelirium luteum* and *Sanicula marilandica* in bloom, both SH species not seen in the state for 50 years, along with *Zizia aptera* at its third DE station.

The Mill Run drainage provided the largest population of *Dryopteris goldiana* in the state. In the White Clay valley, finds included thousands of plants of *Corydalis flavula* growing along an old railroad bed on E. I. DuPont property, and the largest population yet for *Aplectrum hyemale* in the state. Finally, on the Piedmont outliers of Iron Hill and Chestnut Hill south of Newark, additional populations of S1 species *Eupatorium sessilifolium* and *Angelica venenosa* were found on the former while the SH species *Veronicastrum virginicum* was found on the latter on I-95 roadbank.

In the Fall Line zone and Coastal Plain of central and southern New Castle County, a number of rare species were found to be much more common than previously thought. A chance stop along a roadside led to the discovery of large populations of both *Alopecurus carolinianus* and *A. aequalis*, at that time both S1 DE species, along with the alien *Myosurus minimus*, a new state record. Further searches of the same habitats—wet mucky fallow cornfields—revealed an abundance of both grasses along with several stations of a new state record, *Myosotus macrosperma* (first discovered in the White Clay valley), causing some concern about its nativity and whether or not the two grasses have beocme naturalized in this habitat since Tatnall's flora of 1946. A third grass previously thought quite rare but perhaps more common than previously recorded, *Glyceria acutiflora*, was found in several Carolina Bays and may be in many more. *Deschampsia flexuosa*, previously a DE SH species, was rediscovered at Noxontown Pond and at several other stations in like habitat—steep slopes under oaks with little or no leaf litter in firm soils.

An unusual upland Piedmont-like habitat under and near a powerline cut in the Sandy Branch drainage, first noted at the end of the 1991 highlights, yielded *Angelica venenosa* (one plant in flower), *Caltha palustris*, *Ceanothus americanus*, *Deschampsia flexuosa*, *Helianthemum propinquum*, *Helianthus divaricatus*, and *Paronychia canadensis*. This was the first Coastal Plain record for *H. divaricatus*. A small population of *Luzula acuminata*, just across the state line in MD, was also found. *Solidago arguta* was also discovered in a similar but much smaller habitat along Drawyers Creek. A list of other Coastal Plain highlights included *Callitriche terrestris* (DE SH) at a degraded pond south of Wilmington, *Aster infirmus* (DE SH) and *Agalinis tenuifolia* (DE S1) in the Blackbird region (the latter probably soon to be eradicated by housing), *Cornus stricta* (new state record) in a freshwater marsh near the Appoquinomink where *Equisetum fluviatile* had recently been rediscovered by Keith Clancy, *Scutellaria galericulata* and *Juncus torreyi* (both S1) in the marshes near Deemer's Beach, three stations for *Hedyotis uniflora* (along with *Isoetes engelmannii* at one of them) that extends its range north to New Castle County, *Malaxis unifolia* near Cedar Swamp, *Matelea caroliniensis* in fruit and flower on the DE/MD state line, and a station for *Hypericum drummondii* (new state and second Delmarva record) near Glasgow on DuPont property in central New Castle County. JANET EBERT AND JACK HOLT

Bartonia No. 58: 141-147, 1994

1991 FIELD TRIPS

April 26: Pine Barrens of Burlington and Ocean cos., NJ. This trip was a bus tour co-sponsored by the Divison of Pinelands Research at Rutgers University and the club in conjunction with our symposium of April 25, "Research Perspectives in the Pinelands." On the previous evening, trip participants heard Ted Gordon's slide-illustrated lecture, "Flora and Habitats of the Pine Barrens," a preview of some of the selected sites. En route, David Fairbrothers presented a capsuled history of botanists who explored the Pine Barrens since the 18th century. At the Pinelands Biosphere Reserve Research Center near New Lisbon we were met by Ralph Good and students, who presented an overview of their current and past research. Our first stop was a mature upland oak-pine forest near the Lebanon Headquarters. At the next stop at Shinn Branch, we compared three forest types: pitch pine lowland, white cedar swamp, and pine-blackjack oak. We proceeded to the Lower (East) Plains where possible causes of stunting of this pygmy forest were discussed. The root crown of the blackjack oak (*Quercus marilandica*) was excavated to expose lignotubers, which were the subject of considerable discussion. Our final stop was a lowland pitch pine forest at Atison. Here we assessed the impact of a severe wildfire (1983) on species composition and rare herbs. Leaders: David E. Fairbrothers, Alfred E. Schuyler, William Olson, Joseph Arsenault, and Ted Gordon.

May 4: Mount Cydonia Ponds and Mountain Run Ponds, Franklin Co., PA. This trip emphasized the seasonal wetlands that occur along the west flank of South Mountain. They were filled with water on the date of the excursion. We examined two of the Mount Cydonia Ponds, which are in the Michaux State Forest south of Caledonia State Park; and three of the Mountain Run Ponds, which are on private land east of Scotland, Pa. Noteworthy finds included two large stands of *Woodwardia virginica*, a spectacular floral display of *Orontium aquaticum*, plus flowering populations of *Aronia arbutifolia*, *Vaccinium corymbosum*, *Nuphar lutea*, and *Carex vesicaria*. The taxonomic difficulties in *Aronia* were discussed. The surrounding forests also contained several species in bloom: *Rhododendron periclymenoides*, *Cornus florida*, *Viola fimbriatula*, *V. primulifolia*, *Cypripedium acaule*, and (in bud) *Isotria verticillata*. In the late afternoon, we observed vegetative plants of *Iris verna* in a pitch pine-scrub oak barren along the Appalachian Trail on "Big Flat" (the summit of South Mountain). Subsequently, while returning to Caledonia, we were pleased to find this species in bloom on a grassy roadside along Route 233. Leaders: Larry Klotz and Jeffrey Walck.

May 5: Licking Creek, Franklin Co., PA. We began by visiting a mesic upland woods on the limestone and calcareous shale of the Onondaga and Old Port formations. The forest overstory mostly consisted of *Acer saccharum*, *Liriodendron*, *Tilia*, *Quercus* spp., and *Carya* spp. The herbaceous layer was luxuriant and had an unusual composition for southcentral Pennsylvania. Notable herbs were *Delphinium tricorne* (including one plant with very pale purple flowers), *Ranunculus micranthus* (as well as *R. abortivus*), *Jeffersonia diphylla*, *Vicia caroliniana*, *Chaerophyllum procumbens*, *Hydrophyllum macrophyllum* (as well as *H. virginianum*), *Phacelia purshii*, *Phlox divaricata*, *Aster shortii*, *Carex jamesii*, and *Trillium sessile*. The unexpected find was a cluster of 15 shoots of *Corallorhiza wisteriana*. In this same woods was a shale outcrop with *Juniperus virginiana*, *Viola pedata* (both concolorous and bicolorous corollas), *Antennaria plantaginifolia*, and several small-flowered herbs such as *Lithospermum arvense*, *Myosotis verna*, and *Veronica arvensis*.

After lunch in Robert Hunter's yard, we visited another upland woods, this time on the Wills Creek Formation. Some of the notable species that we observed were *Ranunculus hispidus*, *Dodecatheon amethystinum*, *Matelea obliqua*, *Phacelia dubia*, and *Carex platyphylla*. Along the roadside we encountered *Lithospermum canescens* and *Zizia aptera*.

We then crossed Licking Creek into Maryland to observe a calcareous cliff. Here we saw *Asplenium trichomanes*, *A. rhizophyllum*, *A. resiliens*, *Pellaea atropurpurea*, *Galium boreale*, *Aquilegia canadensis*, and *Sedum telephioides*. Leaders: Jeffrey Walck and Larry Klotz.

June 8: Bowmans Hill State Wildflower Preserve, Bucks Co., PA. Among the flowering plants seen were: *Pyrularia pubera*, *Dicentra eximia*, *Carex grayi*, *Gaylussacia brachycera*, *Lonicera sempervirens* and *Paxistima canbyi*. Some of the fern species encountered include: *Diplazium pycnocarpon*, *Deparia acrostichoides*, *Matteuccia struthiopteris*, *Cystopteris protusa*, *C. bulbifera*, *Dryopteris goldiana*, *D. cristata*, *D. clintoniana*, *Cheilanthes lanosa* and *Polystichum braunii*. In addition, a tour of the propagation area at Bowmans Hill was given by propagator, Tom Stevenson. Leader: Bill Olson.

June 23-27: Glassboro, NJ. The 1991 Joint Field Meeting of the Northeastern Sectiuon of the Botanical Society of America, the Torrey Botanical Club, and the Philadelphia Botanical Coub was held at Glassboro State College in Glassboro, New Jersey.

Three days were taken up with field trips. The first day's excursions went to sites in the New Jersey Pine Barrens, including the Atsion ore beds, the East Plains, and to cedar bogs and savannahs north of Pleasant Mills. On the following day, wetlands along the Menantico Creek and Manumuskin River in New Jersey's Cumberland County were visited, as were saltmarshes along Delaware Bay. The last day's trips went to Pennsylvania, to visit Serpentine Barrens in West Chester and at Tyler Arboretum. Trip leaders were Ted Gordon, Karl Anderson, James Stasz, Joseph Arsenault, Bill Olson, Gerry Moore, Heinrich Zoller, Anne Newbold, Jack Holt, and Janet Ebert. Evening programs were presented by Ted Gordon, who spoke about the New Jersey Pine Barrens; by Bill Olson, who discussed New Jersey's Wetland Habitats; by Nancy Kuntzleman, who spoke about Serpentine Barrens; and by George Pierson, who presented a History of Forestry in New Jersey. Chairman: Ted Gordon.

July 13: Oswego River, Burlington Co., NJ. A torrential downpour that in six hours dumped 9 inches of rain on the area made driving almost impossible. Nonetheless, nine seasoned veterans—four from out-of-state—convened at Jenkins. During a lull in the storm, it was agreed to attempt botanizing at Martha. We had just recorded *Lobelia nuttallii*, *Cladium mariscoides*, and *Oxypolis rigidior* var. *longifolia*, when curtains of rain and deepening puddles convinced us to call it a day. Leader: Ted Gordon.

July 20: Palmyra, Burlington Co., NJ. The focus of this trip was on adventive plants that were noted on a walk into an overgrown dredge spoil area along the Delaware River, south of Route 73. Some that appeared thoroughly naturalized on the site included *Cyperus amuricus*, *Polygonum orientale*, *Sorghum halapense*, and perhaps *Datura innoxia* and *Petunia violacea*. Present, but probably only as short-lived artifacts of leaf-dumping, were such plants as *Sorghum vulgare*, *Cleome spinosa*, *Ipomaea purpurea* (Morning Glory), *Portulaca grandiflora* (Moss-rose), *Tagates* sp. (Marigold), *Curcurbita pepo* (Pumpkin), and *Lycopersicon esculentum* (Tomato). A few other plants seenon this site included *Populus deltoides* which is the dominant tree on most of the area, *Urtica dioica* which is also abundant, and *Hibiscus palustris*, *Humulus japonicus*, *Digitaria* (*Leptoloma*) *cognatum*, *Croton glandulosus*, *Mirabilis nyctaginea*, *Rumex verticillatus*, *Froehlichia gracilis*, *Helianthus annuus*, and *Heterotheca subaxillaris*. *Geranium pusillum*, small but attractive, was found growing in a vacant lot along Route 73. Leader: Karl Anderson.

July 27-28: Tuckahoe River/Belleplain State Forest, Atlantic, Cape May, Cumberland cos., NJ. This trip began in the Peaslee Wildlife Management Area at Hunters Mill in Cumberland County where along a gravel road the group saw large populations of the rare spurge *Crotonopsis elliptica*. Along a powerline, the following species were recorded: *Amphicarpum purshii*, *Andropogon virginicus*, *A. glomeratus*, *Aster dumosus*, *Carex complanata*, *C. striata*, *Desmodium ciliare*, *D. viridiflorum*, *Eleocharis palustris*, *E. tenuis*, *Eupatorium album*, *E. hyssopifolium*, *E. pilosum*, *E. rotundifolium*, *Helianthemum canadense*, *H. propinquum*, *Hypericum canadense*, *H. hypericoides*, *Lechea pulchella*, *Lespedeza procumbens*, *Liatris graminifolia*, *Lycopodium alopecuroides*, *Muhlenbergia uniflora*, *Panicum dichotomum*, *Pinus rigida*, *P. verrucosum*, *P. virgatum*, *Polygala cruciata*, *P. lutea*, *P. nuttallii*, *Quercus falcata*, *Rhexia mariana*, *R. virginica*, *Rhynchospora alba*, *R. capitellata*, *R. macrostachya*, *Schizachyrium scoparium*, *Solidago odora*, *Xyris difformis*, *X. torta, and X. smalliana*.

An intermittent pond just north of the powerline cut that was devoid of water in most places, had saplings of *Acer rubrum*, *Liquidambar styraciflua*, and *Pinus rigida* scattered in the pond. The herbaceous layer was dominated by *Cladium mariscoides*. A few patches of *Panicum hemitomon*, rare in New Jersey, were noted. The rare *Lobelia canbyi* was present along with *Carex striata*, *Drosera intermedia*, *Erianthus giganteus*, *Juncus canadensis*, *Panicum verrucosum*, *Proserpinaca pectinata*, *Rhexia virginica*, *Rhynchospora alba*, *R. chalarocephala*, *Vaccinium corymbosum*, *V. macrocarpon*, and *Xyris difformis*.

Along the path leading to an intermittent pond south of the powerline cut, we saw the rare *Hedyotis uniflora*. This pond was inundated with water to depths of 3 to 6 inches. Rare species found here were *Coreopsis rosea* and *Panicum hemitomon*. *Brasenia schreberi*, *Nymphaea odorata*, *Scirpus subterminalis* (with emergent stems and fruit), and *Vaccinium corymbosum* were also found here.

The group then entered Cape May County en route to yet another intermittent pond in the Peaslee Wildlife Management Area. Rare species in the pond were *Ludwigia linearis*, *Rhynchospora inundata* (large patches present in the center of the pond), *Sclerolepis uniflora*, and *Sphagnum macrophyllum*. Other species included *Carex striata*, *Cladium mariscoides*, *Drosera intermedia*, *Erianthus giganteus*, *Eriocaulon compressum*, *Juncus canadensis*, *J. pelocarpus*, *Panicum ensifolium*, *P. spretum*, *Proserpinaca pectinata*, *Rhexia virginica*, *Xyris difformis*, and *X. smalliana*. Upon leaving the pond, the leader got lost in a woods dominated by *Quercus alba*, *Q. coccinea*, *Q. falcata*, and *Pinus rigida*, with a shrub layer of *Gaylussacia baccata*, *G. frondosa*, and *Vaccinium vacillans*.

The second day of the field trip began at Belleplain State Forest in Cape May County where the group visited an intermittent pond off of Route 550. This pond was devoid of water and dominated by *Muhlenbergia torreyana*. Other rare species included *Eleocharis microcarpa*, *Hypericum denticulatum*, *Lobelia canbyi*, *Panicum wrightianum*, *Rhynchospora*

(*Psilocarya*) sp., *Sceria reticularis*, and *Sphagnum macrophyllum*. The group then visited another pond in the State Forest, south of Steelmantown Road and west of Crossing Road. *Carex striata* was throughout much of the pond with a few stands of *Panicum hemitomon*. Other species included *Dulichium arundinaceum*, *Erianthus giganteus*, *Eleocharis microcarpa*, *Panicum spretum*, *Rhexia virginica*, and *Sphagnum macrophyllum*.

The group's last stop of the day was a tidal marsh along the Tuckahoe River in Tuckahoe to see *Ammannia latifolia*, *Liliaeopsis chinensis*, and *Lythrum lineare*. Leader: Gerry Moore.

August 3: Paulinskill Creek area and Stokes State Forest, Sussex Co., NJ. A walk along the Paulinskill Creek on an abandoned railroad right-of-way produced a plant list which included: *Hepatica nobilis* var. *obtusa*, *Actaea pachypoda*, *Epigaea repens*, *Helianthus divaricatus*, *Heliopsis helianthoides*, *Aster cordifolius*, *Sanguinaria canadensis*, *Lobelia syphilitica*, *Melanthium hybridum*, *Polypodium virginianum*, *Asplenium platyneuron*, *A. trichomanes*, *A. ruta-muraria*, *Woodsia obtusa*, and *Pellaea* × *atropurpurea*. Within the creek itself, the following species were encountered: *Potamogeton natans*, *P. crispus*, and *Heteranthera dubia*. A short distance away, we explored selected areas in Stokes State Forest. On the road to Sunrise Mountain, we encountered *Sorbus americana*, *Betula papyrifera*, and *Eupatorium sessilifolium*. Our final stop at the Steam Mill area produced the following species: *Glyceria canadensis*, *Lindernia dubia*, *Penthorum sedoides*, *Lysimachia ciliata*, *Silene stellata*, and *Lobelia cardinalis*. This trip was a joint trip with the Torrey Botanical Club. Leader: Bill Olson.

August 10: Mad Horse Creek Fish and Wildlife Mangement Area, Lower Alloway Creek Township, Salem Co., NJ. Members explored the southern corner of Salem County's tidal wetlands and adjacent upland. Mad Horse Creek is a State owned parcel located on the west side of Stow Creek. This area is dominated by a Delaware Bay brackish tidal marsh with small, beaded chains of upland islands scattered throughout the marsh. We began our trip by the Artificial Island Nuclear Power Plant causeway. From this vantage point, we had access to a well maintained dirt road through the wetlands.

Along this route there was a dense ground cover of *Carex debilis*, *C. swanii*, *C. complanata*, and *Chasmanthium laxum* under the upland forest canopy of *Liquidambar styraciflua*, *Quercus phellos*, *Q. falcata*, and *Acer rubrum* var. *trilobum*. *Pinus taeda* was identified as a forest associate throughout the Fish and Wildlife Management Area. It was interesting to note the presence of typically tidal species such as *Spartina alterniflora* (dominant), *Hibiscus moscheutos*, and *Spartina cynosuroides* intermixed with the non-tidal wetland species along the edge of the access road. Other species found along this road included *Aralia spinosa* in very dense thickets, and a dense ground cover of *Cyperus amuricus* in recently disturbed areas under the powerlines.

After lunch, the group drove to the Pine Island Boat Launch at the end of Stow Creek Neck Road, to investigate Pine Island and Stretch Point. We walked a path from the parking lot to Stretch Point through a series of small upland islands surrounded by the salt marsh of Stow Creek. The islands were dominated by *Quercus alba*, *Q. stellata*, *Q. velutina*, *Q. falcata*, *Pinus taeda*, *Liquidambar*, *Nyssa sylvatica*, *Sassafras albidum*, and *Diospyros virginiana* with a dense understory of *Vaccinium corymbosum*, *Myrica pensylvanica*, and *M. cerifera*. Other species included *Eupatorium fistulosum* and *Eleocharis palustris*.

After a brief rest, we drove to the headwaters of Stow Creek, in the vicinity of the village of Jericho, on the Salem-Cumberland County border. The area around the pond and the stream below the dam produced *Tipularia discolor*, *Lobelia cardinalis*, *Chionanthus virginicus*, and *Carpinus caroliniana*. The trip was ended after a brief drive over Coffin Hill. Leader: Joe Arsenault.

August 17: Bennett Bogs Preserve, Lower Township, Cape May Co., NJ. After being almost continually flooded since 1988, these intermittent ponds were finally free of standing water for this trip. Although *Habenaria nivea* was not encountered, a number of species not seen for a few years reappeared. These included: *Rhynchospora filifolia*, *Psilocarya nitens*, and *Scleria reticularis*. Other species included *Eryngium aquaticum*, *Hydrocotyle umbellata*, *Sium suave*, *Aster dumosus*, *Bidens connata*, *Boltonia asteroides*, *Sclerolepis uniflora*, *Viburnum nudum*, *Hypericum boreale*, *Proserpinaca pectinata*, *P. palustris*, *Lycopus amplectans*, *Lindernia anagallidea*, *Carex vesicaria*, *Eleocharis melanocarpa*, *Juncus debilis*, *Tipularia discolor*, *Coelorachis rugosa*, *Panicum wrightianum*, and *Xyris difformis*. Leader: Bill Olson.

August 24: Delaware River tidal wetlands, New Castle Co., DE. We began the day at Augustine Beach where we saw plants characteristic of brackish marshes such as *Cyperus filicinus*, *Iva frutescens*, *Kosteletzkya virginica*, *Lilaeopsis chinensis*, *Pluchea odorata*, *Samolus parviflorus*, *Spartina alterniflora*, *S. cynosuroides*, and *S. patens*. There also were plants that extend into the freshwater portion of the Delaware Estuary such as *Amaranthus cannabinus*, *Cyperus odoratus*, *Echinochola walteri*, *Hibiscus moscheutos*, *Phragmites australis*, *Polygonum punctatum*, and *Schoenoplectus pungens*. Farther upstream at Deemers Beach there were fewer brackish species although *Lilaeopsis chinensis* and *Spartina alterniflora* were abundant. Freshwater species not seen at Augustine Beach included *Bidens bidentoides*, *B. laevis*, *Cyperus bipartitus*, *Juncus acuminatus*, *Helenium autumnale*, *Sium suave*, *Peltandra virginica*, and *Pontederia cordata*. Still farther upstream at Bellevue, we saw many more freshwater species including *Cardamine pensylvanica*, *Eleocharis erythropoda*, *E. palustris*, *Heteranthera reniformis*, *Lindernia dubia*, *Ludwigia palustris*, *Sagittaria graminea*, *S. latifolia*, *Schoenoplectus fluviatilis*, *S. tabernaemontani*, and *Zizania aquatica*. Species seen here that are more characteristic of brackish conditions included *Pluchea odorata*, *Samolus parviflorus*, *Solidago sempervirens*, and *Spartina alterniflora*. Leader: Alfred E. Schuyler.

September 14: New Lisbon, Whitesbog, and Lebanon State Forest, Burlington and Ocean cos., NJ. At the Experimental Station in the Lebanon State Forest, we saw *Aster patens*, *A. linariifolius*, *Agalinis setacea*, and an extensive patch of leaves of *Solidago tarda* (*S. ludoviciana*) with just two flowering stems. The latter population, which frequently lacks flowering stems, has persisted here for at least 25 years. Cessation of annual prescribed burns of this site has accelerated shrub growth and diminished the spectacle of fall flowers. Along the banks of Mt. Misery Brook in New Lisbon, we paused to see a vigorously-fruiting colony of *Lygodium palmatum*, a station of long standing. Near the old "Dory" Bogs, east of Magnolia, were *Cyperus strigosus*, *C. dentatus*, *Spiranthes cernua*, *Agalinis purpurea*, and *Solidago elliottii*. East of Retreat, we carefully examined scattered plants of *Spiranthes ochroleuca*, comparing them to a specimen (collected earlier) of the very similiar *S. cernua*. Near our lunch stop at Pakim Pond, a few plants of *Gentiana autumnalis*, growing in association with *Calamovilfa brevipilis*, had escaped mowing. At Woodmansie, in a recently clearcut mature pine/oak stand, there were impressive clumps of *Scleria nitida* and *S.*

pauciflora scattered over about two acres—the largest population of these species known to the leader. It appears that these rare species have benefited from disturbances related to the harvest and/or post-harvest preparation for planting of pine seedlings. At the edge of an abandoned orchard in Pasadena, we saw a cluster of 16 plants of *Aster concolor* and a fine patch of *A. undulatus*. A short visit to Goose Pond produced *Rhynchospora inundata*, *Utricularia purpurea*, *U. subulata* (including forma *cleistogama*), *Xyris difformis*, and possibly *Sagittaria graminea*. A brief search for a small population of *Narthecium americanum*, seen here by the leader several years ago, was unsuccessful. On a road shoulder at Whitesbog, we noted an impressive stand of about 60 plants of *Prenanthes autumnalis* is association with *Liatris graminifolia*, *Calamovilfa brevipilis*, *Scleria triglomerata*, and *Polygala cruciata*. Leader: Ted Gordon.

September 15: Trenton/Hamilton Marshes, Mercer Co., NJ (joint trip with Torrey Botanical Club). We visited cleared areas, lowland forest, marsh edges near Sturgeon Pond, and tidal channel and marsh at Watson's Creek near Robeling Park picnic area. Plant species of interest were *Aristida purpurascens*, *Arthraxon hispidus*, *Bartonia virginica*, *Bidens connata*, *B. discoidea*, *B. laevis*, *Carex trichocarpa*, *Eupatorium altissima*, *Laportea canadensis*, *Lespedeza cuneata*, *Lycopus rubellus*, *Ludwigia peploides*, *Mikania scandens*, *Lycopodium obscurum*, *Phellodendron lavallei*, *Polygonum amphibium*, *Potamogeton pusillus*, *Rumex verticillatus*, *Selaginella apoda*, *Spiranthes cernua*, *Vallisneria americana*, and *Zizania aquatica*. The leaders thank Karl Anderson, Bill Olson, Naomi Dicker, Robert Meyer, Jessie Harris, and others for various identifications. Leaders: Mary and Charlie Leck.

September 21: Sandy Hook National Recreation Area, Monmouth Co., NJ. Joined by members of the New Jersey Audubon Society, we visted a variety of habitats, including sand dunes, woodlands, and salt marsh. Plants of sand dunes and dune fields included *Cyperus filiculmis*, *Opuntia humifusa*, *Helianthus petiolaris*, *Artemisia stelleriana*, the introduced and invasive sedge *Carex kobomugi*, and several grasses, among them *Triplasis purpurea*, *Aristida tuberculosa*, *Cenchrus tribuloides*, and both *Panicum amarum* var. *amarum* and var. *amarulum*. Dune woodlands and thickets dominated by *Celtis occidentalis*, *Ilex opaca*, and *Myrica pensylvanica* also yielded *Aster laevis*, *Rhus aromatica*, *Smilacina stellata*, *Lechea maritima*, *Baccharis halimifolia*, and abundantly-fruiting *Prunus maritima*. The edge of a small salt marsh had *Atriplex arenaria*, *Sueda maritima*, *Chamaesyce polygonifolia*, *Salsola kali*, *Salicornia europaea*, *S. virginica*, *Iva frutescens*, and the expected grasses *Spartina alterniflora*, *S. patens*, and *Distichlis spicata*. The shore of a dune pond produced *Lycopus europaeus*, *Scirpus pungens*, *S. validus*, and *Pluchea odorata*. About a hundred species of plants we looked at during the day. Leaders: Bill Olson and Karl Anderson.

September 28: Presque Isle State Park, Erie Co., PA. Species in the unusual plant communities here included *Juncus alpinus*, *J. brachycephalus*, *J. dudleyi*, *J. articulatus*, *Hemicarpha micrantha*, *Carex aquatilis*, *C. garberi*, *C. viridula*, *C. bebbii*, *Eleocharis quadrangulata*, *Scirpus smithii*, *S. acutus*, *Cyperus diandrus*, *C. engelmannii*, *C. schweinitzii*, *C.* × *nieuwlandii* (*C. flavescens* × *C. bipartitus*), *Panicum tuckermanii*, *Potentilla paradoxa*, *Megalodonta beckii*, *Potamogeton richardsonii*, and *Equisetum laevigatum*. Many of these species are found on the Pennsylvania List of Species of Special Concern. Leader: James K. Bissell.

October 5: Cumberland and Cape May cos., NJ. Thirteen species of asters and nine species of goldenrods were found on this trip. These include *Aster tenuifolius*, *A. subulatus*, *A. pilosus*, *A. dumosus*, *A. vimineus*, *A. patens*, *A. undulatus*, *A. concolor*, *A. nemoralis*, *A. spectabilis*, *A. novi-belgii*, *A. gracilis*, *A. linariifolius*, *Solidago sempervirens*, *S. erecta*, *S. odora*, *S. nemoralis*, *S. rugosa*, *S. uliginosa*, *S. canadensis* var. *scabra*, *Euthamia graminifolia*, and *E. tenuifolia*. Other species of interest were *Setaria magna*, *Scleria nitida*, and *Eupatorium capillifolium*. Near the end of the day, Larry Klotz showed the group Lake Nummy in Belleplain State Forest. There we found *Myriophyllum humile*. Later after the trip, Larry located *Psilocarya scirpoides* in the same area. Leader: Bill Olson.

Bartonia No. 58: 148-154, 1994

1992 FIELD TRIPS

April 12: Lebanon State Forest, Burlington Co., NJ. This trip was primarily for lichens. Locations and habitats visited included oak woods near the State Forest office and at Deep Hollow Pond; a cedar swamp along Shinn's Branch; upland pine forest east of Shinn's Branch; and lowland pine forest along Cooper Road. 39 species of lichens were identified. Foliose species included *Imshaugia aleurites*, *I. placorodia*, *Pyxine sorediata*, *Parmelia sulcata*, *P. squarrosa*, *Phaeophyscia rubropulchra*, *Hypogymnia physodes*, and others. In the fruticose category, four species of *Cladina—Cladina subtenuis*, *C. submitis*, *C. rangiferina*, and *C. arbuscula*—were noted within arm's reach of each other. As expected, many species in the genus *Cladonia* were seen; some of them were *Cladonia atlantica*, *C. bacillaris*, *C. clavulifera*, *C. floridana*, *C. pleurota*, *C. rappii*, *C. strepsilis*, and *C. cristatella*. A few additional species, mostly crustose, were identified only to genus. Among the few flowering plants in bloom were *Pyxidanthera barbulata*, *Draba verna*, and *Cardamine hirsuta*—the last two as "weeds" in the lawn of the Lebanon State Forest office. Leader: Karl Anderson.

April 18: Shenks Ferry and Susquehanna River Glens, Lancaster Co., PA. We started the trip at the Holtwood Dam overlook where we saw *Pinus pungens*, *Woodsia obtusata*, *Asplenium pinnatifidum*, and *Viola fimbriatula*. From there we travelled south along the river to an unnamed glen adjacent to the Route 372 bridge (east side of river) where we searched to no avail for *Asplenium bradleyi*. We did, however, see a large patch of *Asplenium montanum*. We travelled north along the river to Tucquan Glen where we did see a small patch of *Asplenium bradleyi*. The glen also had a good population of *Trillium erectum* and *Claytonia virginica*. The last stop was at Shenk's Ferry Glen. At the glen we saw numerous plants of *Mertensia virginica*, *Hybanthus concolor*, *Trillium flexipes/erectum*, *Erythronium americanum*, and *Claytonia virginica*. We searched to no avail for *Corallorhiza wisteriana*. The plants were seen at the location two weeks later. Leader: Mark Larocque.

April 25: Inner Coastal Plain at Vincentown and Pine Barrens, Burlington Co., NJ. We explored a limestone ravine of the Vincentown Formation bordering the South Branch of Rancocas Creek from the village of Vincentown west to the Hatcher Farm. Well known to geologists and paleontologists, this ravine, rich in foraminifera and bryozoan fossils, apparently has been little investigated by botanists. Here, within one mile of the Pine Barrens, lies an outstanding example of a mature palustrine forest of mixed *Quercus*, *Carya*, *Liquidambar styraciflua*, *Acer rubrum*, *A. negundo*, *Platanus occidentalis* (13 ft, 2.5 in cbh), *Liriodendron tulipifera* (8 ft, 9.5 in cbh), *Ulmus americana* (9 ft, 1 in cbh), *Fagus grandifolia*, *Betula nigra* (7 ft, 4.5 in cbh), *Tillia americana*, *Carpinus caroliniana*, *Cornus florida*, and *Celtis occidentalis*. Herb and shrub diversity is especially high and includes *Aquilegia canadensis*, *Erythronium americanum*, *Corylus americana*, *Polystichum acrostichoides*, *Cystopteris tenuis*, *Viburnum acerifolium*, *Rhododendron periclymenoides*, *Heuchera americana*, *Chelone glabra*, *Goodyera pubescens*, *Luzula multiflora*, *Euonymus americanus*, *Carex comosa*, *Cornus amomum*, and *Geum canadense*. Several species that are infrequent or local on the inner coastal plain are here too: *Panax trifolium*, *Phegopteris* *hexagonoptera*, *Staphylea trifolia*, *Polypodium virginianum*, and *Tsuga canadensis*. (Stone cites only 3 southern New Jersey stations for Broad Beech Fern and 7 for Hemlock.) Rare species seen here are *Cercis canadensis* and *Geum vernum*. In the afternoon we vistied sections of the Rancocas Cranberry Company at Ongs Hat to see *Aletris farinosa*, *Amianthium muscaetoxicum*, *Botrychium matricariaefolium*, *Carex vestita*, *C. barrattii*, *Krigia biflora*, and *Helonias bullata*. In a Lebanon Forest cedar swamp near Four Mile we saw another population of the latter species, associated with *Orontium aquaticum*. Leaders: Joseph Arsenault and Ted Gordon.

April 26: Salem and Cumberland cos., NJ. In the woods and ravines of Salem Creek near Woodstown we saw *Alisma subcordatum*, *Allium tricoccum*, *Arisaema triphyllum*, *Cardamine concatenata*, *C. hirsuta*, *Dicentra cucullaria*, *Geum canadense*, *Hydrastis canadensis*, *Hydrophyllum virginianum*, *Iris pseudacorus*, *Lysimachia nummularia*, *Osmorhiza longistylis*, *Podophyllum peltatum*, *Polemonium reptans*, *Polygonatum biflorum*, *Ranunculus abortivus*, *Sambucus canadensis*, *Sicyos angulatus*, *Sparganium americanum*, *Veratrum viride*, and *Viola pubescens*. A side trip was made to Bridgeton to see *Helonias bullata* along Roadstown Road. Leader: Michael O'Brien.

May 9: Bowman's Hill Wildflower Preserve, Bucks Co., PA. Various trails through the preserve were visited. *Mertensia virginica* was in full bloom in the low moist woodlands. In the trail guide for the area this species is listed as blooming in early April. Perhaps due to the cool April weather, these plants, and many others, were retarded in their development so that many were not in full bloom on this trip. But altogether, about 25 species of herbs were found flowering in scattered locations. A few plants of *Silene virginica* were observed in flull bloom while one specimen of *Chrysogonum virginianum* was noted. Handsome specimens of *Trillium grandiflorum* and *T. erectum* were seen as was one luxurious bloom of *Caltha palustris*. Plants that were past bloom on this trip included *Erythronium americanum*, *Epiagaea repens*, *Dicentra cucullaria*, *D. canadensis*, *Sanguinaria canadensis*, and *Jeffesonia diphylla*. Only four grasses were observed in bloom; these were *Anthoxanthum odoratum*, *Poa annua*, *P. pratensis*, and *Dactylis glomerata*. Leader: Robert Meyer.

May 16: Wissahickon Valley, Philadelphia Co., PA. Along Bells Mill Road and downstream along Wissahickon Creek, we encountered a mixture of native and non-native flora. Native herbs included *Actaea pachypoda*, *Arisaema triphyllum*, *Circaea lutetiana*, *Claytonia virginica*, *Collinsonia canadensis*, *Erigeron philadelphicus*, *Erythronium americanum*, *Medeola virginiana*, *Podophyllum peltatum*, *Polemonium reptans*, *Polygonatum pubescens*, *Ranunculus abortivus*, *R. caricetorum*, *R. recurvatus*, *Viola affinis*, *V. cucullata*, *V. pubescens*, and *V. sororia*. Non-native herbs included *Aegopodium podograria*, *Alliaria petiolata*, *Allium vineale*, *Artemisia vulgaris*, *Cardamine impatiens*, *Duchesnea indica*, *Glecoma hederacea*, *Hesperis matronalis*, *Lysimachia nummularia*, *Ornithogalum umbellatum*, *Ranunculus bulbosus*, *R. ficaria*, *R. repens*, *Stellaria media*, and *Verbascum phlomoides*. A similar mixture of native and non-native woody plants and vines were also observed. Some of these that were non-native included *Berberis thunbergii*, *Celastrus orbiculatus*, *Cercidophyllum japonicum*, *Deutzia scabra*, *Euonymus alatus*, *E. europaeus*, *Hedera helix*, *Ilex crenata*, *Ligustrum vulgare*, *Lonicera japonica*, *L. maackii*, *Rhodotypos scandens*, *Viburnum plicatum*, and *V. sieboldii*. Numerous other species were recorded to compare with those in the unpublished checklist prepared by John Fogg in the 1950s.

Leaders: Sioux Baldwin and Alfred E. Schuyler.

June 6: Iron Hill, New Castle Co., DE. We spent the day exploring this monadnock named for its long-abandoned iron mines. Starting at the parking lot the party observed a few plants of *Liparis lilifolia* in bloom. Further along in the paths, we encountered, among other species, *Oxalis violacea, Scutellaria elliptica, Angelica venenosa,* and a large colony of *Aristolochia serpentaria,* along with the featured species of the trip, large quantities of *Ophiglossum pycnostichum* with tongues almost fully exserted. We then followed a trail through mature oak-beech-tulip woods toward Route 896 on the estern edge of the hill, noting on the way populations of *Galearis spectabilis, Pyrola elliptica,* and *P. rotundifolia.* We then bushwhacked through the woods in an unsuccessful search for a population of *Melanthium hybridum* reported a few years back, but did encounter *Adiantum pedatum* along with *Obolaria virginica* which was a new discovery for Iron Hill, before returning via a different trail back to the parking lot for lunch. After lunch, we explored a road cut along I-95, where we encountered *Spergularia marina* along the road, and on the banks such species as *Veronicastrum virginicum, Quercus stellata, Sisyrinchium mucronatum* (just past full bloom), young plants of *Scleria pauciflora,* and *Lobelia spicata* (still in bud). Leaders: Janet Ebert and Jack Holt.

June 21-25: Chambersburg, PA. The 1992 Joint Field meeting of the Philadelphia Botanical Club, the Torrey Botanical Club, and the Northeastern Section of the Botanical Society of America was housed at Wilson College in Chambersburg. Three days were taken up with field trips. The first day's excursions went to sites along the Appalachian Trail in Cumberland County, including swamps, dry woods, and the floodplain of the Conodoguinet Creek. On the following day, the Altona Marl Marsh in West Virginia, and the C & O Canal near Sharpsburg, Maryland, were visited. On the last day, trips went to Caledonia State Park, a beautiful area, and to intermittent ponds on South Mountain. Trip leaders were Greg Edinger, Larry Klotz, John Kunsman, Bill Olson, Rodney Bartgis, Kathy Bilton, and Robert and Fanny Johnsson. Evening programs were presented by Wallace Drexler, who spoke about Pennsylvania Geology; Robert Johnsson, who gave a fine program about the C & O Canal; Rodney Bartgis, who discussed endangered plants of Maryland; and Eugene Wingert, who spoke about the fauna of the South Mountain ponds. Charman: Larry Klotz; Treasurer: Karl Anderson.

July 11: Oswego River Savannah and Turfcut, Burlington Co., NJ. Near the confluence of Buck Run and the Oswego River, we visited a quaking savannah that, during a severe dry spell, was swept by a devastating fire on June 22, 1986, extending to the river's edge. The narrow band of *Chamaecyparis thyoides* saplings that ringed the savannah was consumed by the fire; however, the cedars in the wettest sloughs survived. During the first two years after the fire, the proliferation of such grasses as *Andropogon glomeratus, A. virginicus, Calamovilfa brevipilis, Panicum virgatum, Agrostis perennans* var. *elata,* and *Danthonia epilis* by now had diminished remarkably. No other enduring impacts of the fire were observed at this time. Vigorous populations of *Sarracenia purpurea* were thriving in iron-stained pools, overtopped by the white heads of *Eriocaulon decangulare,* replacing the decomposing heads of *E. compressum.* Rising above lush carpets and hummocks of sphagnum were the yellow racemes of *Narthecium americanum,* the fuzzy inflorescences of *Lophiola aurea,* the bright yellow spikes of *Utricularia cornuta,* and the white flowers of

Tofieldia racemosa. Among associates were *Juncus caesariensis*, *J. canadensis*, *Carex livida*, *C. exilis*, *C. folliculata*, *Cladium mariscoides*, *Sabatia difformis*, *Pogonia ophioglossoides*, *Calopogon tuberosus*, and *Utricularia fibrosa*. In a nearby turfcut downstream, dominated by *Drosera filiformis* and *Utricularia cornuta*, we again saw *Narthecium* scattered with *Lophiola* plus fine pockets of *Schizaea pusilla* and *Lycopodium carolinianum*. Bladder-bearing plants of *Utricularia purpurea* were submersed in an adjacent canal. Since our visit, the NJ Natural Areas Council has been apprised of the species richness of this savannah and turfcut, and is considering its incorporation within the boundaries of the existing Oswego Natural Area. Leader: Ted Gordon.

July 18, 19: Manumuskin River, Muskee Creek, and Tuckahoe River; Atlantic, Cape May, and Cumberland cos., NJ. The trip began in the headwaters of the Manumuskin River in Buena Vista Township where we visited a chain of vernal ponds. The first pond was devoid of water and was dominated by two rare species, *Coreopsis rosea* and *Panicum wrightianum*. Other species present in this pond included: *Scleria reticularis*, *Viola lanceolata*, and *Xyris difformis*. In the second pond, the outer edges were dominated by zones of *Carex striata*, *Panicum spretum*, and *Woodwardia virginica*. In the wetter inner areas of the pond, *Eleocharis robbinsii*, *Eriocaulon aquaticum*, *E. compressum*, *Nymphaea odorata*, *Sagittaria englemanniana*, *Utricularia fibrosa*, *Xyris difformis*, and *X. smalliana* were recorded. The third and final pond was much less diverse, being dominated by *Cephalanthus occidentalis* and *Dulichium arundinaceum*. After leaving the ponds, *Aletris farinosa*, *Lechea minor*, *L. mucronata*, *Plantago lanceolata*, *P. major*, *P. rugelii*, and *Scleria triglomerata* were recorded in an open, dry area adjacent to an abandoned building. Moving on to an open wetland adjacent to a farm field near the railroad crossing along Landis Avenue, south of Richland, we keyed out the following sedges: *Carex barrattii*, *C. striata*, *Cyperus dentatus*, *Eleocharis microcarpa*, *E. obtusa*, *E. olivacea*, *E. tenuis*, *E. tricostata*, *E. tuberculosa*, *Rhynchospora capitellata*, and *R. fusca*. Our keys were of little help for the large bed of *Scirpus* that dominated one area of the wetland. No flowering or fruiting material was present, and we could only wonder whether this was the rare *S. longii*, which has historically been reported from here, or the common *S. cyperinus*. Also noted was *Proserpinaca intermedia*. The last stop of the day was a cedar swamp in the headwaters of the Muskee Creek in Maurice River Township. The following herbs were noted on the corduroy road that led into the swamp: *Drosera intermedia*, *D. rotundifolia*, *Eriophorum virginicum*, *Lycopodium appressum*, *Panicum mattamuskeetense*, *Pogonia ophioglossoides*, and *Polygala lutea*. A very large white cedar was noted just off the corduroy road. On the next day, we recorded a circumference of approximately 9½ ft at breast height for this tree, which makes it the lagest living Atlantic white cedar for NJ. Also in this cedar swamp, we visited an open pond, which had over 3 ft of standing water and was dominated by *Scirpus subterminalis* and *Utricularia fibrosa*. Farther east in the Tuckahoe River watershed, we visited a vernal pond in the Peaslee Wildlife Management area. In the inner wetter areas of the pond there were large stands of the rare *Rhynchospora inundata* and *Sclerolepis uniflora*. A large stand of *Erianthus giganteus* dominated the outer edges of the pond. The *Rhexia* that dominated some areas of the pond appeared to be *R. virginica* with appressed leaves. Later these plants were identified as *R. aristosa* by Robert Kral. They differ, however, from plants of *R. aristosa* at the type locality in Atlantic County in a number of characteristics (e.g., leaf width, leaf margin, sepal lobe position, seed surface). A careful systematic study of New Jersey's *Rhexia* appears to be warranted. Our last stop was another vernal pond, north of the Head-of-River Cemetery. This pond was dominated by *Carex striata*, *Eleocharis robbinsii*, *Eriocaulon compressum*, and *Panicum spretum*. A very small stand of *Rhynchospora inundata* was also here. The woodland path that led to the pond from County Route 666 was dominated in places by the state rare *Crotonopsis elliptica*; the rare violet, *Viola brittoniana*, was also noted along this path. Leader: Gerry Moore.

July 25: Whitesbog and Vicinity, Ocean and Burlington cos., NJ. The morning was spent exploring damp, peaty roadsides in the vicinity of Whitesbog, a historic cranberry-blueberry village that is now part of Lebanon State Forest. A large and diverse assemblage of plants included *Habenaria blephariglottis* just coming into bloom, *Calopogon tuberosus* at the end of its blooming season, *Spiranthes gracilis*, *Polygala lutea*, *P. brevifolia*, *Galactia regularis*, *Schwalbea americana*, *Drosera filiformis*, *D. intermedia*, *D. rotundifolia*, *Scleria triglomerata*, *Juncus biflorus*, some interesting oaks including *Quercus stellata*, *Q. marilandica*, and *Q. prinoides*, and numerous species of ericaceous shrubs. A post-lunch visit to Webb's Mills produced *Schizaea pusilla*, *Lycopodium carolinianum*, *Lophiola aurea*, *Sarracenia purpurea*, *Triadenum virginicum*, *Sabatia difformis*, *Narthecium americanum*, and three species of *Utricularia* including *U. fibrosa*, *U. cornuta*, and *U. juncea*. The final stop was a sandy swale along an old railroad bed near Roosevelt City. Here, we found that a stand of *Eupatorium resinosum*, a globally-rare species, had been recently mowed, probably by a utility line maintenance crew. Only a few plants remained standing. Leader: Karl Anderson.

August 1: Goat Hill Serpentine Barrens, Chester Co., PA. The barrens had been burned during a wildfire during the last winter so the plants were very vigorous. *Ascelpias verticillata* was in full bloom with greater numbers of plants than seen there previously. We also saw *Asclepias viridiflora*, *Sporobolis heterolepis*, *Liparis loeselii* (first known Chester Co. record), *Sabatia angularis*, *Helianthus giganteus*, and *Vernonia noveboracensis*. After lunch at Harold Sweetman's house, we hiked into the southern end of the barrens to see the Federally Endangered chickweed, *Cerastium arvense* var. *villosissimum*. We also saw *Arisaema dracontium* and *Campanula rotundifolia*. Four hardy people plus myself ventured to Nottingham Park to search for *Spiranthes vernalis* to end the day. Leader: Mark Larocque.

August 15: Lehigh Pond, Wayne Co., PA. This trip started with a visit to an excellent example of a glacial bog natural community at Lehigh Pond. Here we saw concentric vegetation zones on a floating peat mat surrounding an open body of water. The shrub mat was dominated by *Chamaedaphne calyculata*, *Kalmia angustifolia*, *K. polifolia*, *Spiraea latifolia*, and *S. tomentosa*. Open peat areas were dominated by numerous sedges such as *Carex canescens*, *C. lasiocarpa*, *C. limosa*, *C. paupercula*, *C. stricta*, *C. trisperma*, *Dulichium arundinaceum*, and *Eriophorum virginicum*. Insectivorous species were also abundant including *Drosera intermedia*, *D. rotundifolia*, and *Sarracenia purpurea*. Other plants of interest were *Platanthera blephariglottis* (in bloom), *Andromeda polifolia*, *Ledum groenlandicum*, *Menyanthes trifoliata*, and *Solidago uliginosa*. After lunch at Tobyhanna State Park, the group headed to State Game Lands No. 127 to see a large stand of *Myrica gale*, growing with *Nemopanthus mucronata* and *Rhododendron canadense*. Leader: Greg Edinger.

August 29: Hutcheson Memorial Forest, Somerset Co., NJ. We explored the successional fields (aged 3–30 years) and a part of the forest of this ecological research property. The "old forest" has lost most of the large trees in recent decades due to drought, gypsy moth damage, hurricanes, and natural mortality, but some older oaks were noted. One of the more dramatic research projects showed the vegetation effects of deer and rodent exclosure fences. Some of the plants observed were *Pycnanthemum muticum*, *Quercus robur*, a variety of *Solidago* (*S. nemoralis*, *S. juncea*, *S. rugosa*, *S. gigantea*, *S. altissima*, *S. canadensis*), *Euthamia graminifolia*, *Helianthus giganteus*, *Cornus racemosa*, and *C. amommum*. In mid-afternoon we made an excursion to another property of Rutgers University, the Display Garden and Helyar Woods at Cook College, New Brunswick. The public garden is noted for trails of new varieties and its perennial collections (e.g. hollies, dogwoods, and other ornamental trees). Helyar Woods was seen to be a healthy climax forest dominated by beech, oaks, and hickories. Leaders: Mary and Charlie Leck.

September 12: Cecil, Gloucester Co., NJ. Two pine barren edge locations were explored on the border of Monroe and Franklin townships for roadside fall composites and successional conditions found in two sand and gravel pits. Along a stretch of Blue Bell Road, between Malaga Road and Coles Mill Road, we found *Solidago odora*, *S. rugosa*, *S. puberula*, *S. erecta*, *S. nemoralis*, *S. ludoviciana*, *S. juncea*, *Asterleariifolius*, *A. undulatus*, *A. umbellatus*, *A. gracilis*, *A. spectabilis*, *A. novi-belgii*, *Liatris graminifolia*, *Lespedeza repens*, *Desmodium rotundifolium*, *D. marilandicum*, *D. paniculatum*, *Danthonia spicata*, and *Epigaea repens*. This rich assemblage is found on the infrequently mowed roadside adjacent to an oak-pine forest. We investigated an abandoned gravel pit on the north side of Blue Bell Road that was in an early successional stage ten years after being abandoned. Observations and comments were made on the continued bank erosion and movement of all surface soils. The few plants that invaded this unstable, dry, open habitat included *Aristida longspica*, *Diodea teres*, *Digitaria filiformis*, *Andropogon virginicus*, *Panicum virgatum*, and *Euthamia tenuifolia*. After lunch, we inspected and compared the conditions of slopes of a restored section of Arrowwood Nursery. This site was planted with oaks (black, white, post, bear, chestnut, red), pitch pines, old field composites and grasses seven years ago. Restoration definitively improves the success of plants becoming established on soils without any nutrient retention. The slope soil surfaces were completely covered. The soil was sealed with a lichen, algae, moss, and fungi surface crust which supported grasses and old field composites common in dry fields in Southern New Jersey. Limiting foot traffic, incorporating a carbon source into the soil, and eliminating stream flow erosion are keys to success. Native species found on the uplands included *Solidago speciosa*, *S. ludoviciana*, *Polygala polygama*, and *Aster spectabilis*. Wetland habitats supported numerous sedges and rushes, including *Cyperus dentatus*, *C. iria*, *Xyris difformis*, *Spiranthes cernua*, and *Juncus pelocarpus*. Later at a gravel excavation in Winslow Fish and Wildlife Management Area we found a colony of *Eleocharis quadrangulata* discovered earlier by Mr. Ben Gindville, the only known recent record for this species in Camden County. Additional species discovered included *Scleria triglomerata*, *Carex barrattii*, *Rhynchospora gracilenta*, *R. fusca*, *R. macrostachya*, and *Leiophyllum buxifolium*. Leader: Joe Arsenault.

October 3: Craven's Estate, Natural Lands Trust, near Sumneytown, Montgomery Co., PA. The "Potato Patch," a lichen covered field of diabase rock—the type also known as Ringing Rocks—is home to *Corydalis sempervirens*, *Arabis laevigata*, and *Polypodium virginanum*.

Across the dirt road is a wild flower field filled with *Pycnanthemum tenuifolium*, *P. virginianum*, *Heliopsis helianthoides*, *Cirsium muticum*, *Solidago speciosa*, *S. rigida*, *Gentianopsis crinita*, *Gentiana andrewsii*, *Zanthoxylum americanum*, *Dirca palustris*, etc. Thirteen ferns were found on the Trust's land. We started with a pre-recorded list of 314 plants to which we added 21 more. Jack Holt's orchidean eye spotted *Liparis lilifolia*, *Goodyera repens*, and *Corallorhiza odontorhiza*. In the afternoon we walked up to "Indian Alleys," the cave area reported to be the home of some Lenni-Lenapes of yesteryear. Leaders: Ann Newbold and Henrich Zoller.

Bartonia No. 58: 155-159, 1994

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Program of Meetings 1991 and 1992

Date	*Subject*	*Speaker*
1991		
24 Jan	The Pause that Refreshes: 1791-1891-1991. Botany in Philadelphia and Suburbs	Joseph Ewan
28 Feb	John and William Bartram Jointly sponsored with the John Bartram Association	Elizabeth P. McLean
28 Mar	Rare and Endangered Species Symposium. Coordinated by Ann F. Rhoads. Jointly sponsored with the Morris Arboretum	
25 & 26 Apr	Research Perspectives in the Pinelands. Symposium coordinated by David E. Fairbrothers & Ralph E. Good. Jointly sponsored with Rutgers University	
23 May	Gardens of the Philadelphia Area Jointly sponsored with the Pennsylvania Horticultural Society	Peggy Bowditch
26 Sep	The Collector's Garden	William M. Klein, Jr.
24 Oct	Changes in Our Flora with a Comparison to Barton's 1818 Flora	Alfred E. Schuyler
21 Nov	Wetlands Flora: Diversity, Function, and Importance. Symposium coordinated by Jane Rowan. Jointly sponosored with the Academy of Natural Sciences, Stroud Water Research Center	
19 Dec	Changing Ecology of our Biosphere	Ruth Patrick
1992		
23 Jan	Hunting Dendrobium Orchids in New Zealand, Australia, New Guinea, and Fiji	Howard P. Wood
27 Feb	Rare Plants of the Piedmont of Chester County, Pennsylvania	Robert J. Holt
26 Mar	American Lotus (*Nelumbo lutea*) in New Jersey and Pennsylvania	William S. Ettinger
23 Apr	Asymmetric Competition in Plant Populations	Jacob Weiner
28 May	Savannahs, Quaking Bogs, Turfcuts and Cedar Swamps of the New Jersey Pine Barrens	Ted Gordon
24 Sep	Slide Illustrated Report of Summer Botanizing	Club Members
22 Oct	New Jersey Ferns and Fern Allies	James Montgomery
19 Nov	Dr. Darlington's Medical Botany Revisited (1854)	Dorothy Lansing
17 Dec	Orchids of North America	Mark Larocque

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ISSN 0198-7356

BARTONIA

JOURNAL OF THE PHILADELPHIA BOTANICAL CLUB

No. 59

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PUBLISHED BY THE CLUB
ACADEMY OF NATURAL SCIENCES, 1900 BENJAMIN FRANKLIN PARKWAY
PHILADELPHIA, PENNSYLVANIA 19103-1195
Issued 4 September 1996

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Annotated Checklist of the Plants of the Wissahickon Valley

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JOHN M. FOGG, JR.[1]

Interest in the plant-life of the Wissahickon Valley dates back more than two and a half centuries. In 1694 the German Pietists, under the leadership of Kelpius, established in the lower Wissahickon a garden for the growing of medicinal plants. Doubtless many of the native plants of the Valley were cultivated by them for their real or supposed therapeutic values.

The region was well known to John Bartram, founder of another famous garden on the banks of the Schuylkill River, and during the first half of the nineteenth century the Valley was visited by Frederick Pursh and Thomas Nuttall, two of the most distinguished students of the flora of eastern North America. Throughout the latter half of the last century the Wissahickon was a botanical hunting ground for such eminent naturalists and botanists as Joseph Leidy, Joseph T. Rothrock, Thomas C. Porter, and J. B. Brinton. Unfortunately, these men, although well acquainted with the plants of the Valley, collected few if any specimens, and left almost no record of the occurrence of individual species.

Between 1900 and 1925 the Wissahickon was the scene of considerable botanical activity. Two botanists in particular, S. S. Van Pelt and Henry A. Lang, made numerous collections in the Valley and their specimens are in the herbaria of the Philadelphia Academy of Natural Sciences, and the University of Pennsylvania. Although Mr. Van Pelt was careful to note on his labels the localities from which his plants were collected, Mr. Lang's specimens are usually designated merely "along the Wissahickon Creek" or "Wissahickon Creek Ravine," and we have no means of knowing the exact source of his material.

In 1937-38 the Friends of the Wissahickon established a fellowship to a graduate student at the University of Pennsylvania for the purpose of making a botanical survey of the Valley. The holder of the fellowship was Mr. Ernest H. Ludwig, then a student of the present author. Mr. Ludwig performed a valuable service by going through the mounted collections at the Academy and the University and listing all of the specimens from the Valley. He also did some collecting of his own, but his work was interrupted by the war, and his specimens were never labeled or mounted.

In 1953, at the instigation of the Hon. Harold D. Saylor, Vice President of the Friends of the Wissahickon, the author undertook to revise and edit Mr. Ludwig's compilation and to augment it with his own observations based on many years' acquaintance with and countless walks in the valley.

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[1] This checklist is posthumously published through the urging of the **Friends of the Wissahickon** with the hope that it will stimulate renewed interest in recording the present status of the Wissahickon flora. Current nomenclature has been added in parentheses to correspond with Rhoads and Klein (1993). Similarly, changes in family designations have been indicated by placement of the current family name, where it differs from that used by Fogg, in parentheses. For information about Dr. Fogg see Hill, Farley, and Fogg 1983.

The present list is admittedly incomplete. Many species doubtless still remain to be discovered. Others reported as rare may prove to be abundant. Still others, included on the basis of older collections, may no longer be members of the present-day flora. The list is offered at this time in the hope that it may stimulate those who are interested in the plant-life of the Valley to make and report their own observations to the end that a really comprehensive and up-to-date checklist may be assembled.

The following list includes the more important and familiar of higher (vascular) plants believed to occur in the Valley of the Wissahickon Creek from the Schuylkill River to Northwestern Avenue in Chestnut Hill, including the extensions into the Cresheim Valley and along Bells Mill Road. Omitted from the enumeration are several families which, while of interest to the botanist, contain forms which are either so inconspicuous or so difficult to classify, that their inclusion in a popular check-list seems inadvisable. Among these are the grasses (*Gramineae*), sedges (*Cyperaceae*), and rushes (*Juncaceae*). Those desiring to study these groups should consult one of our standard manuals or floras, such as *Gray's Manual of Botany* (Fernald 1950), *The New Britton and Brown Illustrated Flora of the Northeastern United States and Adjacent Canada* (Gleason 1952), or *Manual of Vascular Plants of Northeastern United States and Adjacent Canada* (Gleason & Cronquist 1991).

The arrangement of the families in this list conforms in general to that found in the above works. Within each family, however, the sequence of genera and species is, for the sake of convenience, alphabetical.

SUMMARY OF SPECIES AND VARIETIES

	Native	Introduced	Total
Pteridophytes	36	0	36
Gymnosperms	5	2	7
Monocotyledons	37	12	49
Dicotyledons	417	145	562
TOTALS	495	159	654

LIST OF LOCALITIES PROCEEDING UPSTREAM

Mouth of Creek, Reading R. R. Bridge, Gipsy Lane, Picnic Grounds, Hermit's Lane, Henry Avenue, Paper Mill Run, Bluestone Bridge, Indian Profile Rock, Walnut Lane, Roxborough Avenue, Kitchen's Lane, Monastery, Leverington Street, Carpenter's Woods, Mount Airy Avenue, Gorgas Lane, Livezey Lane, Devil's Pool, Cresheim Creek , McCallum Street, Bog Garden, Lake Surprise, Valley Green, Springfield Avenue, Hartwell Lane, Wise's Mill Road, Summit Avenue, Paper Mill, Rex Avenue, Indian Rock Bridge, Tedyuscung Statue, Thomas Mill Road, Red Covered Bridge, Bells Mill Road, (Thorps Lane), Barren Hill Road, Northwestern Avenue, Harper's Meadow, Germantown Avenue.

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PTERIDOPHYTES

EQUISETACEAE, HORSETAIL FAMILY

Equisetum arvense. Common horsetail. Fairly frequent in low ground. Appearing early spring. Walnut Lane, Valley Green, Rex Avenue.

LYCOPODIACEAE, CLUB-MOSS FAMILY

Lycopodium lucidulum (*Huperzia lucidula*). Shining club-moss. Rich woods, usually in deep humus. Uncommon. Rex Avenue, Thomas Mill Road.

Lycopodium obscurum. Flat-branched ground-pine. Dry woods and thickets. Known from only a few localities, e.g. above Hartwell Avenue.

SELAGINELLACEAE, SPIKE-MOSS FAMILY

Selaginella apoda. Meadow spike-moss. Small, inconspicuous plant suggesting a moss in appearance. Found occasionally in meadows or grassy clearings. Gorgas Lane, Cresheim Valley.

OPHIOGLOSSACEAE, ADDER'S TONGUE FAMILY

Botrychium dissectum. Lace-leaf grape-fern. Fairly frequent on moist to dry wooded slopes of the ravine. Hartwell Avenue.

Botrychium obliquum (*B. dissectum*). Coarse-lobe grape-fern. Same occurrence, and often with *B. dissectum*. Bells Mill Road.

Botrychium virginianum. Rattlesnake-fern. Rich, deciduous woods. Fairly common throughout Wissahickon and Cresheim valleys, especially northward. Shawmont Avenue, Kitchen's Lane.

OSMUNDACEAE, FLOWERING FERN FAMILY

Osmunda cinnamomea. Cinnamon fern. Low, damp ground, meadows, etc. Locally abundant, especially in the upper portion. Rex Avenue, Thomas Mill Road.

Osmunda claytoniana. Interrupted fern. In similar habitats, but less frequent than *O. cinnamomea*. Valley Green, Thomas Mill Road.

Osmunda regalis. Royal fern. Wet woods and thickets. Rare. Known only from Bells Mill Road west of creek.

POLYPODIACEAE, FERN FAMILY

(Adiantaceae)

Adiantum pedatum. Maiden-hair fern. Rich, deciduous woods. Occasionally met in the upper Wissahickon. Rex Avenue.

(Aspleniaceae)

Asplenium pinnatifidum. Lobed spleenwort. Crevices of rock outcrops. Rare. Not seen in recent years.

Asplenium platyneuron. Ebony spleenwort, brownstem spleenwort. Open woods, wooded slopes, rock faces, etc. Only occasional throughout the ravine. Thomas Mill Road.

Asplenium trichomanes. Maiden-hair spleenwort. Damp, shaded crevices and rock ledges. Infrequent, but known from three or four localities in the ravine. Thomas Mill Road.

Camptosorus rhizophyllus (*Asplenium rhizophyllum*). Walking fern. Shaded rock ledges. Rare. Thomas Mill Road.

(Blechnaceae)

Woodwardia areolata. Broad-leaved chain fern. Wet woods, swamps, etc. Rare. Rex Avenue.

(Dennstaedtiaceae)

Dennstaedtia punctilobula. Hay-scented fern. Common throughout in open, shaded woods, rock faces, damp slopes, etc. One of the most abundant ferns in the area. Henry Avenue, Bluestone Bridge, Walnut Lane, Kitchen's Lane, Livezey Lane, Valley Green, Rex Avenue, Thomas Mill Road, Bells Mill Road, Thorps Lane.

Pteridium aquilinum. Bracken fern. A variable species represented in our area chiefly by the variety *latiusculum*. Dry woods, clearings. Occasional. Hartwell Avenue, along bridle path south of Bells Mill Road.

(Dryopteridaceae)

Athyrium angustum, var. *rubellum* (*A. filix-femina* var. *angustum*). Northern lady fern. Moist woods and thickets. Fairly common. Kitchen's Lane, Valley Green, Rex Avenue, Bells Mill Road.

Athyrium asplenoides (*A. filix-femina* var. *aspleniodes*). Southern lady fern. Similar habitats, but less frequent than *A. angustum*. Thomas Mill Road.

Athyrium thelypteroides (*Deparia acrostichoides*). Silvery spleenwort. Rich woods and shaded slopes. Plentiful throughout. Henry Avenue, Walnut Lane, Livezey Lane, Cresheim Valley, Valley Green, Rex Avenue, Thomas Mill Road, Bells Mill Road.

Cystopteris fragilis var. *mackayii* (*C. tenuis*). Fragile fern. Damp rocks, stony outcrops, open woods, etc. Fairly common. Walnut Lane, Cresheim Valley, Thomas Mill Road.

Dryopteris cristata. Crested wood fern. Rich woods. Rare. Thomas Mill Road.

Dryopteris goldiana. Giant wood fern. Rich woods. Rare, known only from second ravine above mouth of creek.

Dryopteris marginalis. Marginal wood fern. Rich woods, rocky slopes. Fairly frequent. Henry Avenue, Walnut Lane, Livezey Lane, Cresheim Valley, Thomas Mill Road.

Dryopteris spinulosa (*D. intermedia*). Common wood fern. A variable species, represented in our area by the variety *intermedia*. Dry to moist woods and thickets. Walnut Lane, Cresheim Valley, Valley Green, Rex Avenue, Thomas Mill Road, Bells Mill Road.

Onoclea sensibilis. Sensitive fern. Low woods and thickets, open ground along trails, etc. Frequent throughout. Hermit's Lane, Bluestone Bridge, Walnut Lane, Carpenter's Woods, Cresheim Valley, Thomas Mill Road.

Polystichum acrostichoides. Christmas fern. Woods, shaded and often rocky slopes. Common throughout. Walnut Lane, Kitchen's Lane, Livezey Lane, Cresheim Valley, Valley Green, Rex Avenue, Thomas Mill Road, Bells Mill Road.

Pteretis pensylvanica (*Matteuccia struthiopteris*). Ostrich fern. Rich woods, bottomland, etc. Rare. Known only from bog garden along Cresheim Creek, and below Harper's Meadow.

Woodsia obtusa. Blunt-leaved cliff fern. Rock ledges, dry woods, etc. Infrequent, known only from Wise's Mill Road and above Thorps Lane.

(Polypodiaceae)

Polypodium virginianum. Rock fern. Rocks, crests of ledges, cliff faces, etc. Of very local occurrence in steep, shaded areas of ravine. Thomas Mill Road, Bells Mill Road.

(Thelypteridaceae)

Thelypteris dryopteris. Oak fern. Dry woods. Rare. Known only from near Graver's Lane.

Thelypteris hexagonoptera. Broad beech-fern. Rich to dry woods. Rare. Hartwell Avenue.

Thelypteris novaboracensis. New York fern. Dry to damp woods, slopes and thickets. Common throughout. Walnut Lane, Livezey Lane, Cresheim Valley, Rex Avenue, Thomas Mill Road, Bells Mill Road.

Thelypteris palustris. Marsh fern. A wide-ranging species, represented in our area by the variety *pubescens*. Swamps, meadows, wet thickets. Occasional in more open sections of the valley and along Cresheim Creek.

Thelypteris phegopteris. Long beech-fern. Woods and thickets. A northern species found many years ago near Thomas Mill Road; locality obliterated by Japanese honeysuckle.

GYMNOSPERMS

PINACEAE, PINE FAMILY

(Cupressaceae)

Juniperus virginiana. Juniper, red cedar. Dry slopes, clearings. Occasional in open woods, especially on slopes and summits of ridges. Bluestone Bridge.

(Pinaceae)

Pinus nigra var. *austriaca*. Austrian black pine. Planted in certain areas, e.g: near Walnut Lane Bridge.

Pinus rigida. Pitch pine. Occasional on slopes and summits of ridges. Along bridle trail above Thomas Mill Road.

Pinus strobus. Eastern white pine. Although white pine may originally have occured in the valley, the trees growing here today are the result of recent plantings. A fine grove exists along Hermit's Lane near Hermit Street.

Pinus sylvestris. Scots pine. Planted in several areas and possibly naturalized.

Pinus virginiana. Scrub pine. Probably persisting from earlier plantings. Occasional on dry, rocky slopes and crests; near mouth of creek, Carpenter's Woods, below Bells Mill Road.

Tsuga canadensis. Hemlock. One of the commonest and most handsome trees of the valley. Often forming pure stands, especially on the west or north facing slopes, as at: Walnut Lane, Valley Green, south of Rex Avenue, above Covered Bridge.

MONOCOTS

ALISMACEAE, WATER-PLANTAIN FAMILY

Sagittaria australis. Southern arrow-head. Shallow water. Collected in the valley in 1908, but no locality given. Perhaps no longer present.

Sagittaria latifolia. Common arrow-head. Shallow water and muddy shores. Infrequent. Above Walnut Lane.

ARACEAE, ARUM FAMILY

(Acoraceae)

Acorus calamus. Sweet flag. Marshes, wet meadows. Very local. Cresheim Valley, Harper's Meadow.

(Araceae)

Arisaema triphyllum. Jack-in-the-pulpit. Woods and thickets. Common. Henry Avenue, Bluestone Bridge, Walnut Lane, Kitchen's Lane, Carpenter's Woods, Cresheim Creek, Mt. Airy Avenue, Valley Green, Rex Avenue, Bells Mill Road, Harper's Meadow.

Symplocarpus foetidus. Skunk cabbage. Wet meadows and thickets, swampy woods. Common in bottomland. Henry Avenue, Walnut Lane, Kitchen's Lane, Mt. Airy Avenue, Cresheim Creek, Allen's Lane, Thomas Mill Road, below Bells Mill Road.

COMMELINACEAE, DAYFLOWER FAMILY

Commelina communis. Dayflower. Low, moist ground, roadsides, etc. Fairly common throughout the valley. Naturalized from Asia. Bluestone Bridge, Walnut Lane, Livezey Lane, Valley Green, Thomas Mill Road, Bells Mill Road.

Tradescantia virginiana. Spiderwort. Woods, thickets, meadows. Occasional. Probably naturalized from farther south. Thorps Lane.

PONTEDERIACEAE, PICKERELWEED FAMILY

Heteranthera reniformis. Mud plantain. Collected many years ago from shallow water in the lower Wissahickon. Not seen recently and possibly extirpated.

LILIACEAE, LILY FAMILY

Aletris farinosa. Colicroot, star-grass. Dry sand and gravel. Rare. Gorgas Lane.

Allium tricoccum. Wild leek. Rich woods and bottomland. Conspicuous in spring because of its elliptic, fleshy leaves which soon die, leaving the flowers to appear on naked stalks in early summer. Rare and local. Mt. Airy Avenue, Rex Avenue, Thomas Mill Road, Bells Mill Road.

Allium vineale. Field garlic. A troublesome weed, naturalized from Europe and found commonly along trails in grassy clearings, etc. Near mouth of creek, Walnut Lane, Carpenter's Woods, Valley Green.

Asparagus officinalis. Asparagus. Escaped from cultivation and often persistent in disturbed ground.

Chamaelirium luteum. Devil's bit. Rich to dry woods and thickets. Rare in upper valley; not collected since 1910.

Convallaria majalis. Lily-of-the-valley. Occasional as an escape from gardens bordering the valley.

Erythronium americanum. Trout-lily, dogtooth-violet. Rich to sandy woods and thickets, bottomland. Fairly frequent throughout. Henry Avenue, Bluestone Bridge, Kitchen's Lane, Mt. Airy Avenue, Cresheim Creek, Valley Green, Rex Avenue, Thomas Mill Road, Bells Mill Road.

Hemerocallis fulva. Day-lily. Frequently established. Kitchen's Lane, Cresheim Creek, Thomas Mill Road.

Hosta plantaginea. Plantain-lily. Sparingly escaped from cultivation. Below Mt. Airy Avenue.

Hosta ventricosa. Plantain-lily. Frequent as an escape. Henry Avenue, Cresheim Creek, Valley Green, Rex Avenue.

Maianthemum canadense. Wild lily-of-the-valley. Woods, thickets and dry clearings. Frequent throughout. Above Henry Avenue, Bluestone Bridge, Walnut Lane, Mt. Airy Avenue, Cresheim Creek, Bells Mill Road.

Medeola virginiana. Indian cucumber-root. Rich woods. Fairly common. Kitchen's Lane, Livezey Lane, Cresheim Creek, Valley Green, Rex Avenue, Thomas Mill Road.

Muscari botryoides. Grape-hyacinth. Introduced and naturalized from Europe. Occasional in woods and clearings. Thomas Mill Road.

Ornithogalum umbellatum. Star-of-Bethlehem. Introduced and naturalized from Eurasia. Fairly common in woods, thickets, and bottomland. Henry Avenue, Bells Mill Road, Kitchen's Lane, Thomas Mill Road.

Polygonatum canaliculatum (*P. biflorum* var. *commutatum*). Great Solomon's-seal. Woods, thickets and rich bottomlands. Fairly frequent. Mt. Airy Avenue, Cresheim Valley, Harper's Meadow.

Polygonatum pubescens. Small Solomon's-seal. Rich woods and rocky slopes. Occasional. Henry Avenue, Carpenter's Woods, Valley Green, Rex Avenue, Bells Mill Road.

Scilla sibirica. Siberian squill. Established in rich woods. Rare. Thomas Mill Road.

Smilacina racemosa. False Solomon's-seal. Woods and clearings. Frequent throughout. Henry Avenue, Bluestone Bridge, Walnut Lane, Carpenter's Woods, Kitchen's Lane, Mt. Airy Avenue, Cresheim Valley, Valley Green, Rex Avenue, Thomas Mill Road, Bells Mill Road, Harper's Meadow.

Tricyrtis hirta. Toad-lily. Introduced and naturalized from Asia. An occasional escape from gardens bordering the valley. Hartwell Avenue.

Trillium cernuum. Wake-robin, nodding trillium. Rich woods and thickets. Rare. Thomas Mill Road.

Uvularia sessilifolia. Bellflower. Rich woods. Kitchen's Lane, Thomas Mill Road.

(Smilacaceae)

Smilax glauca var. *leurophylla.* Sawbrier. Occasional in dry, rocky woods. Henry Avenue, Walnut Lane, Carpenter's Woods, Thomas Mill Road, Bells Mill Road.

Smilax herbacea. Carrion-flower. Woods and alluvial thickets. Infrequent. Walnut Lane, Thomas Mill Road.

Smilax rotundifolia. Common greenbrier. Moist to dry woods and thickets. Known from several localities in the ravine. Hermit's Lane, Carpenter's Woods, Valley Green, Thomas Mill Road, Bells Mill Road.

AMARYLLIDACEAE, AMARYLLIS FAMILY

(Liliaceae)

Hypoxis hirsuta. Yellow star-grass. Dry woods and clearings. Occasional. Cresheim Creek, Valley Green, Bells Mill Road.

Narcissus pseudo-narcissus. Daffodil. Locally escaped from cultivation. Thomas Mill Road.

DIOSCOREACEAE, YAM FAMILY

Dioscorea villosa. Wild yam. Dry woods and thickets. Apparently rare. Known from Carpenter's Woods and from location one-quarter mile below Bells Mill Road.

IRIDACEAE, IRIS FAMILY

Iris pseudoacorus. European yellow iris. Naturalized near Harper's Meadow.

Sisyrinchium angustifolium (*S. graminoides*). Broad-leaved blue-eyed-grass. Dry woods and thickets. Occasional in the ravine.

Sisyrinchium mucronatum. Narrow-leaved blue-eyed-grass. Similar habitat to *S. angustifolium*. Rare. Known only from the upper Wissahickon.

ORCHIDACEAE, ORCHID FAMILY

Corallorhiza odontorhiza. Autumn coral-root. Rich to dry woods, often in deep humus. Rare.

Corallorhiza wisteriana. Coral-root. Rich woods. Collected somewhere in the valley in 1839. Not seen in recent years and probably extirpated.

Cypripedium acaule. Pink moccasin-flower. Dry woods and clearings. Rare. Bells Mill Road.

Cypripedium parviflorum var. *pubescens* (*C. calceolus* var. *pubescens*). Mocassin-flower. Rich woods. Collected in the valley many years ago. Not recently observed.

Goodyera pubescens. Downy rattlesnake-plantain. Moist to dry woods and thickets. Known only from extreme upper portion of the valley. Thorps Lane, Chestnut Hill.

Isotria verticillata (*Pogonia verticillata*). Purple five-leaved orchid. Extremely rare. Known only from slope above Bells Mill Road.

Liparis lilifolia. Twayblade. Rich to loamy woods. Rare. Hartwell Avenue.

Malaxis unifolia. Adder's-tongue. Rich woods. Rare. Known only from near Devil's Pool.

Orchis spectabilis (*Galearis spectabilis*). Showy orchid. Rich woods. Rare. Found in recent years only below Livezey Lane.

Spiranthes cernua. Common ladies'-tresses. Low, wet woods and thickets. Infrequent. Along Cresheim Creek, Thorps Lane.

Spiranthes gracilis (*S. lacera* var. *gracilis*). Slender ladies'-tresses. Open woods and thickets. Rare. Known only from Thomas Mill Road.

Triphora trianthophora. Three-birds. Collected in the 1860's at the extreme upper end of the valley, and not rediscovered in recent years. Probably obliterated.

DICOTS

SAURURACEAE, LIZARD'S TAIL FAMILY

Saururus cernuus. Lizard's tail. Muddy shores. Occasional near mouth of creek. Not recently seen probably due to pollution of river.

SALICACEAE, WILLOW FAMILY

Populus grandidentata. Large-toothed aspen. Dry woods. Infrequent. Carpenter's Woods, Cresheim Valley, Thomas Mill Road, below Bells Mill Road.

Populus tremuloides. Quaking aspen. Dry slopes. Apparently rare. Carpenter's Woods.

Salix babylonica. Weeping willow. Occasional as an escape in low, damp ground. Near Reading R.R. bridge, Bluestone Bridge, Carpenter's Woods, Lake Surprise, Harper's Meadow.

Salix caprea. Goat willow. Introduced from Europe. Rare in the ravine.

Salix fragilis. Crack willow. Occasional along stream banks. Often a good-sized tree.

Salix nigra. Black willow. Usually a shrub. Wet thickets and stream banks. Infrequent. Carpenter's Woods, Mt. Airy Avenue, Cresheim Valley.

Salix purpurea. Basket willow. Introduced from Europe for basket making and occasionally escaped. Known only from west bank above Reading R.R. bridge and near Bells Mill Road.

Salix sericea. Silky willow. Damp thickets. Cresheim Valley.

MYRICACEAE, WAX-MYRTLE FAMILY

Comptonia peregrina. Sweet-fern. Occasional on dry, acid slopes in the upper Wissahickon, Thomas Mill Road.

JUGLANDACEAE, WALNUT FAMILY

Carya alba (*C. tomentosa*). Mockernut. A tall, handsome tree, found usually on dry, west-facing slopes.

Carya cordiformis. Bitternut, swamp hickory. Stream banks. Known only from lower valley, where rare.

Carya glabra. Pignut. Dry woods and slopes. Not common. Near mouth of creek, Bluestone Bridge, Gorgas Lane, above Bells Mill Road.

Carya ovata. Shag-bark hickory. Rich woods, bottomland. Sporadic throughout. Carpenter's Woods, Cresheim Creek.

Juglans cinerea. Butternut. Occasional in rich woods.

Juglans nigra. Black Walnut. Fine specimens occur in rich woods, e.g: Hermit's Lane, Walnut Lane, Cresheim Valley, Valley Green, Harper's Meadow.

CORYLACEAE, HAZEL FAMILY
(Betulaceae)

Alnus glutinosa. European alder. Occasional as an escape from cultivation. Picnic grounds below Henry Avenue.

Alnus serrulata. Common alder. Occasional along margin of streams and in low, wet ground. Walnut Lane, Cresheim Valley.

Betula lenta. Sweet, black, or cherry birch. Common throughout. Walnut Lane, Devil's Pool, Cresheim Valley, Valley Green, Thomas Mill Road, Bells Mill Road.

Betula nigra. River birch. Low ground, close to the stream. Infrequent. Along both sides of the stream between mouth and Henry Avenue, Bluestone Bridge, Thomas Mill Road, Harper's Meadow.

Betula populifolia. Gray birch. Dry, sterile ground, fields, etc. Occasional. Upper Wissahickon, Carpenter's Woods, Cresheim Valley, above Thomas Mill Road.

Carpinus caroliniana. Hornbeam, Ironwood. Bottomland, usually close to stream. Fairly frequent. Bluestone Bridge, Walnut Lane, Thomas Mill Road, Harper's Meadow.

Corylus americana. Hazel-nut. Thickets. Infrequent. Above Henry Avenue.

Ostrya virginiana. Hop-hornbeam. Bottomland and lower slopes, especially in upper portion of valley, but nowhere common. Thomas Mill Road.

FAGACEAE, BEECH FAMILY

Castanea dentata. American chestnut. Formerly one of our finest trees; today known only as regeneration shoots from old stumps, some of them old enough to bear flowers and fruit, but apparently none resistant to blight. Bluestone Bridge, Thomas Mill Road, Bells Mill Road, Harper's Meadow.

Fagus grandifolia. American beech. Common throughout in low ground and wooded slopes;

good specimens occur near Henry Avenue, Walnut Lane, Carpenter's Woods, Thomas Mill Road, Bells Mill Road, Harper's Meadow.

Quercus alba. White oak. Common throughout in dry ground and on rocky slopes. Henry Avenue, Walnut Lane, Carpenter's Woods, Thomas Mill Road, Bells Mill Road, Harper's Meadow.

Quercus bicolor. Swamp white oak. Bottomland, stream borders. Occasional. Thomas Mill Road.

Quercus coccinea. Scarlet oak. A handsome tree in the autumn. Occasional throughout. Walnut Lane.

Quercus palustris. Pin oak. Occasional in low ground. North of Bells Mill Road.

Quercus prinus (*Q. montana*). Chestnut oak. Dry woods and rocky slopes. Fairly frequent throughout. Henry Avenue, Walnut Lane, Kitchen's Lane, Carpenter's Woods, Livezey Lane.

Quercus rubra. Red oak. A variable tree as to size and shape of leaves. Common throughout in low land and on rich slopes. Hermit's Lane, Henry Avenue, Walnut Lane, Kitchen's Lane, Carpenter's Woods, Cresheim Valley, Rex Avenue, Bells Mill Road.

Quercus velutina. Black oak. Dry woods. Occasional.

ULMACEAE, ELM FAMILY

Celtis occidentalis. Hackberry. Throughout in low ground and wooded slopes. Often distinguished by the presence on the branches of witches-brooms. Near mouth of creek, Hermit's Lane, Walnut Lane, Livezey Lane.

Ulmus americana. Common elm. Rich soil, especially along streams. Occasional in lower valley, especially between mouth of creek and Henry Avenue.

Ulmus rubra. Slippery elm. Usually distinguished from the preceding by its harsh upper leaf surfaces. Common throughout in bottomland and on lower slopes. Mouth of creek, Henry Avenue, Bluestone Bridge, Walnut Lane, Kitchens Lane, Cresheim Valley, Valley Green, Thomas Mill Road, Bells Mill Road.

MORACEAE, MULBERRY FAMILY

Broussonetia papyrifera. Paper mulberry. Introduced from Asia and naturalized sparingly in the valley. Above Henry Avenue.

Maclura pomifera. Osage-orange. Naturalized near mouth of creek.

Morus alba. White mulberry. Native of Asia. Escaped from cultivation and spreading aggressively. Walnut Lane, Kitchen's Lane, Livezey Lane, Cresheim Valley, Thomas Mill Road, Harper's Meadow.

Morus rubra. Red mulberry. Rich woods. Occasional. Hermit's Lane, along west bank below Henry Avenue, near Monastery, Carpenter's Woods.

CANNABINACEAE, HEMP FAMILY

Humulus japonicus. Japanese hop. A comparatively recent introduction from Asia which is rapidly becoming a troublesome weed. Hermit's Lane, Henry Avenue, Kitchen's Lane, Cresheim Valley, Harper's Meadow.

Humulus lupulus. Common hop. Rare and local.

URTICACEAE, NETTLE FAMILY

Boehmeria cylindrica. False nettle. Very abundant in low, moist habitats throughout. Henry

Avenue, Walnut Lane, Kitchen's Lane, Carpenter's Woods, Cresheim Valley, Valley Green, Rex Avenue, Thomas Mill Road, Bells Mill Road, Harper's Meadow.

Laportea canadensis. Wood nettle. Of frequent occurrence in low ground, along paths, etc. Henry Avenue, Walnut Lane, Kitchens Lane, Mt. Airy Avenue, Livezey Lane, Valley Green, Thomas Mill Road, Harper's Meadow.

Parietaria pennsylvanica. Pellitory. Occasional on stone work of bridges, walls, etc.

Pilea pumila. Clearweed. Extremely common in moist ground along drives, bridle paths, etc. Henry Avenue, Walnut Lane, Carpenter's Woods, Cresheim Valley, Valley Green, Rex Avenue, Thomas Mill Road, Bells Mill Road.

Urtica gracilis (*U. dioica* ssp. *gracilis*). Nettle. Open woods, meadows, and clearings. Occasional. Hermit's Lane, Cresheim Valley, Harper's Meadow.

ARISTOLOCHIACEAE, BIRTHWORT FAMILY

Aristolochia durior (*A. macrophylla*). Dutchman's pipe. Rex Avenue, just below Seminole Street.

Asarum canadense. Wild ginger. Woods and shaded slopes. Locally abundant. Henry Avenue, Walnut Lane, Kitchen's Lane, Mt. Airy Avenue, Livezey Lane, Valley Green, Rex Avenue, Thomas Mill Road, above and below Bells Mill Road.

POLYGONACEAE, BUCKWHEAT FAMILY

Polygonum arifolium. Halberd-leaved tearthumb. Moist thickets, infrequent. Walnut Lane.

Polygonum aviculare. Common knotweed. Frequent along trails, foot-paths, clearings, etc.

Polygonum cespitosum var. *longisetum*. Knotweed. A small, branching annual with spikes of purple or roseate flowers. Comparatively recent introduction from southeast Asia. It has spread with phenomenal success and now grows along practically every drive, bridle path, and foot-trail in the valley. Henry Avenue, Bluestone Bridge, Walnut Lane, Kitchen's Lane, Cresheim Valley, Valley Green, Rex Avenue, Thomas Mill Road, Bells Mill Road, Harper's Meadow.

Polygonum convolvulus. Black bindweed. An occasional weed in thickets and waste ground. Cresheim Valley, above Bells Mill Road.

Polygonum cuspidatum. Japanese knotweed. Introduced from east Asia. Tenaciously established at a number of localities, above Henry Avenue, Walnut Lane, Livezey Lane, Carpenter's Woods, Harper's Meadow.

Polygonum lapathifolium. Dock-leaved smartweed. Wet thickets, damp clearings and fields. Occasional. Mt. Airy Avenue, near Germantown Avenue.

Polygonum pensylvanicum. Smartweed. Damp thickets, muddy shores, etc. Bluestone Bridge, Cresheim Valley.

Polygonum persicaria. Lady's-thumb. A frequent weed in damp clearings, ditches, etc. Kitchen's Lane, Mt. Airy Avenue, Cresheim Valley, Harper's Meadow.

Polygonum punctatum. Water smartweed. Abundant in damp hollows, ditches, etc. Henry Avenue, Walnut Lane, Cresheim Valley, Harper's Meadow.

Polygonum sagittatum. Arrow-leaved tearthumb. Low, wet thickets. Occasional. Walnut Lane, Mt. Airy Avenue, Cresheim Valley.

Polygonum scandens. Climbing false buckwheat. Occasional in damp thickets, waste ground, etc. Walnut Lane, Cresheim Valley.

Polygonum tenue. Knotweed. Dry, open, often rocky slopes. Rare. Not recently found.

Rumex acetosella. Sheep sorrel. A common weed along drives, trails, and in disturbed soil of picnic areas, etc.

Rumex altissimus. Sorrel. Alluvial shores. West bank above Reading R.R. bridge.

Rumex crispus. Yellow dock. Occasional in clearings, waste ground, and along drives.

Rumex obtusifolius. Bitter dock, great dock. Occasional in low, wet ground or clearings. Bluestone Bridge, Walnut Lane, Kitchen's Lane, Mt. Airy Avenue, Cresheim Valley.

Tovara virginiana (*Polygonum virginianum*). Virginia jumpseed. Extremely common on moist, shaded banks, in bottomland, woods and thickets. Henry Avenue, Bluestone Bridge, Walnut Lane, Kitchen's Lane, Carpenter's Woods, Cresheim Creek, Valley Green, Rex Avenue, Bells Mill Road.

CHENOPODIACEAE, GOOSEFOOT FAMILY

Chenopodium album. Lamb's quarters. An occasional weed in fields, clearings, etc. Flowers in June or July.

Chenopodium ambrosioides. Mexican-tea. Occasional as a weed in old fields, clearings, etc. Hermit's Lane, Walnut Lane, Cresheim Valley.

Chenopodium missouriense (*C. album* var. *missouriense*). Goosefoot. Resembles *C. album* in appearance and distribution, but flowers in August or September. Walnut Lane, Cresheim Valley.

Chenopodium standleyanum (*C. boscianum*). Goosefoot. Dry woods. Occasional in lower portion of valley.

AMARANTHACEAE, AMARANTH FAMILY

Amaranthus hybridus. Pigweed. A weed in clearings, disturbed soil, etc. Walnut Lane.

PHYTOLACCACEAE, POKEWEED FAMILY

Phytolacca americana. Pokeweed. Rich, low ground, clearings, etc. Common. Henry Avenue, Walnut Lane, Kitchen's Lane, Carpenter's Woods, Mt. Airy Avenue, Livezey Lane, Cresheim Valley, Valley Green, Rex Avenue, Thomas Mill Road, Bells Mill Road.

AIZOACEAE, CARPETWEED FAMILY

(Molluginaceae)

Mollugo verticillata. Carpetweed. Occasional as a weed along paths, in clearings, etc. Henry Avenue, Mt. Airy Avenue.

CARYOPHYLLACEAE, PINK FAMILY

Arenaria serpyllifolia. Thyme-leaved sandwort. Dry fields, roadsides, etc. Bells Mill Road.

Cerastium nutans. Nodding mouse-ear chickweed. Rich woods, bottomland. Occasional.

Cerastium vulgatum (*C. fontanum* ssp. *triviale*). Common mouse-ear chickweed. Frequent along trails, in clearings, etc. Cresheim Creek.

Dianthus armeria. Deptford pink. Frequent in grassy clearings and along drives. Valley Green, Rex Avenue.

Paronychia canadensis. Forked chickweed. Occasional on dry, rocky slopes in upper portion of valley. Thorps Lane.

Paronychia fastigiata. Whitlow-wort. Same habitat as *P. canadensis*. Rare. Thorps Lane.

Sagina procumbens. Pearlwort. Occasional along paths, in open spots in woods, and along gravelly shores. Below Henry Avenue.

Saponaria officinalis. Soapwort, bouncing-bet. Clearings and along roadsides. Fairly frequent. Livezey Lane, Thomas Mill Road, (picnic ground), Bells Mill Road, Harper's Meadow.

Silene antirrhina. Sleepy catchfly. Clearings, waste places. Infrequent.

Silene cucubalus (*S. vulgaris*). Bladder campion. Damp woods and thickets. Not common.

Silene stellata. Starry campion. Woods and clearings. Bluestone Bridge, Thomas Mill Road, Harper's Meadow.

Stellaria alsine (*S. uliginosa*). Chickweed. Springheads, wet banks, etc. Occasional. Thomas Mill Road.

Stellaria graminea. Common stitchwort. Grassland and clearings. Infrequent.

Stellaria longifolia. Long-leaved stitchwort. Deep thickets, meadows and clearings. Infrequent.

Stellaria media. Common chickweed. Common along trails, in damp thickets, and cleared ground. Henry Avenue, Walnut Lane, Kitchen's Lane, Carpenter's Woods, Rex Avenue, Thomas Mill Road.

Stellaria pubera. Great chickweed. Occasional in rich woods. Henry Avenue, Bluestone Bridge, Kitchen's Lane, Mt. Airy Avenue, Bells Mill Road.

PORTULACACEAE, PORTULACA FAMILY

Claytonia virginica. Spring beauty. Common throughout in rich woods, thickets, and clearings. Henry Avenue, Bluestone Bridge, Walnut Lane, Kitchen's Lane, Mt. Airy Avenue, Cresheim Creek, Valley Green, Rex Avenue, Thomas Mill Road, Bells Mill Road.

Portulaca oleraceae. Purslane. Cosmopolitan. Occasional as a weed along trails and in picnic areas. Henry Avenue.

RANUNCULACEAE, BUTTERCUP FAMILY

Actaea pachypoda (*A. alba*). White baneberry, doll's-eyes. Rich woods. Infrequent. Below Valley Green, above Rex Avenue.

Anemone quinquefolia. Wood anemone. Apparently rare and local. Above Bells Mill Road.

Anemone virginiana. Thimbleweed. Dry, open woods and thickets. Infrequent. Walnut Lane, Hartwell Avenue.

Anemonella thalictroides (*Thalictrum thalictroides*). Rue anemone. Rich to dry woods and shaded slopes. Fairly abundant throughout.

Aquilegia canadensis. Columbine. Less frequent than formerly, but still found on rocky ledges, cliffs, etc. Thorps Lane.

Cimicifuga racemosa. Black cohosh. Rich woods. Locally abundant as at Henry Avenue, Walnut Lane, Bells Mill Road, Rex Avenue.

Clematis paniculata (*C. terniflora*). Virgin's bower. Occasionally escaped from cultivation. Hermit's Lane, Walnut Lane, Cresheim Valley.

Hepatica americana (*H. nobilis* var. *obtusa*). Liverleaf. Dry woods and thickets. Not common. Below Rex Avenue, Thomas Mill Road.

Hydrastis canadensis. Goldenseal. Collected in lower Wissahickon around 1910. Not seen in recent years.

Ranunculus abortivus. Kidney-leaved buttercup. Abundant in early spring in rich woods throughout. Henry Avenue, Bluestone Bridge, Walnut Lane, Kitchen's Lane, Carpenter's Woods, Cresheim Creek, Mt. Airy Avenue, Valley Green, Thomas Mill Road, Bells Mill Road.

Ranunculus acris. Tall buttercup. Occasional in clearings, along trails, etc. Not seen in recent years.

Ranunculus bulbosus. Bulbous buttercup. Frequent along trails, in grassy clearings, etc. Thomas Mill Road.

Ranunculus ficaria. Lesser celandine. Established in several localities. Most of ours is the double-flowered variety. Bluestone Bridge, Walnut Lane, Kitchen's Lane, Mt. Airy Avenue, Rex Avenue, Thomas Mill Road.

Ranunculus hispidus. Hairy buttercup. Rich woods. Occasional. Walnut Lane.

Ranunculus recurvatus. Buttercup. Rich woods. Occasional. Kitchen's Lane, Valley Green, Rex Avenue, Bells Mill Road.

Thalictrum dioicum. Early rue. Scattered throughout in woods and thickets.

Thalictrum polygamum (*T. pubescens*). Meadow rue. Meadows and moist thickets. Occasional. Cresheim Valley, Rex Avenue, Valley Green.

MAGNOLIACEAE, MAGNOLIA FAMILY

Liriodendron tulipifera. Tuliptree. Common throughout. Fine specimens occur near Henry Avenue, Walnut Lane, Cresheim Valley, Valley Green, Rex Avenue, Bells Mill Road.

Magnolia acuminata. Cucumber-tree. Planted in a number of places and apparently occasionally established and spreading, e.g: above Rex Avenue.

Magnolia tripetela. Umbrella tree. Planted throughout and occasionally spontaneous. Hermit's Lane, Kitchen's Lane, Mt. Airy Avenue, Cresheim Creek.

Magnolia virginiana. Swamp magnolia. Probably planted, but appearing as though native. Carpenter's Woods.

BERBERIDACEAE, BARBERRY FAMILY

Berberis thunbergii. Japanese barberry. The common Japanese barberry, much planted for hedges, is a frequent escape to wooded slopes along the valley. Henry Avenue, Mt. Airy Avenue, Cresheim Valley.

Caulophyllum thalictroides. Blue cohosh. Occasional in rich woods. Thomas Mill Road.

Podophyllum peltatum. Mayapple. Abundant throughout in woods, thickets, clearings, etc. Henry Avenue, Walnut Lane, Kitchen's Lane, Mt. Airy Avenue, Valley Green, Rex Avenue, Thomas Mill Road, Bells Mill Road, Harper's Meadow.

LARDIZABALACEAE, LARDIZABALA FAMILY

Akebia quinata. Five-leaf akebia. Occasionally escaped from cultivation. Rex Avenue, just below Seminole Street.

LAURACEAE, LAUREL FAMILY

Lindera benzoin. Spicebush. Common everywhere in woods, thickets, on rich slopes, and in bottomlands. Henry Avenue, Bluestone Bridge, Walnut Lane, Kitchen's Lane, Valley Green, Rex Avenue, Thomas Mill Road, Bells Mill Road.

Sassafras albidum. Sassafras. Frequent in dry woods and thickets. Bluestone Bridge, Walnut Lane, Carpenter's Woods, Mt. Airy Avenue, Cresheim Valley, Valley Green, Thomas Mill Road, Bells Mill Road.

FUMARIACEAE, FUMITORY FAMILY

Corydalis flavula. Yellow fumewort. Rocky slopes. Rare. Upper portion of valley.

Dicentra cucullaria. Dutchman's breeches. Rich woods. Rare. Thomas Mill Road, Mt. Airy Avenue.

PAPAVERACEAE, POPPY FAMILY

Chelidonium majus. Celandine. Naturalized from Europe and common in rich, damp soil throughout. Walnut Lane, Livezey Lane, Cresheim Valley, Valley Green.

Sanguinaria canadensis. Bloodroot. Apparently infrequent. More abundant in upper portion of valley. Mt. Airy Avenue, Rex Avenue, Thomas Mill Road, Bells Mill Road.

CRUCIFERAE, MUSTARD FAMILY
(Brassicaceae)

Alliaria officinalis (*A. petiolata*). Garlic-mustard. Fairly common throughout valley in low woods and thickets. Henry Avenue, Bluestone Bridge, Kitchen's Lane, Livezey Lane, Cresheim Creek, Valley Green, Thomas Mill Road, Harper's Meadow.

Arabis canadensis. Sicklepod. Rich woods and rocky banks. Infrequent. Thorp's Lane.

Arabis laevigata. Smooth Rock-cress. Rich woods and shaded slopes. Rare. Henry Avenue, Bluestone Bridge, Mt. Airy Avenue, Kitchen's Lane, Valley Green.

Arabis lyrata. Lyre-leaved rock-cress. Ledges, cliffs, rocky woods. Occasional.

Barbarea vulgaris. Winter cress. This is the plant most commonly known as mustard. It is frequent throughout the valley in meadows, clearings, and along trails. Henry Avenue, Kitchen's Lane, Carpenter's Woods, Valley Green, Rex Avenue, Bells Mill Road.

Brassica arvensis (*Sinapis arvensis*). Mustard. Occasional in clearings and disturbed soil.

Capsella bursa-pastoris. Shepherd's-purse. Frequent as a weed in clearings, waste ground, etc.

Cardamine bulbosa. Spring cress. Occasional in ditches, along streams, about springs, etc. Henry Avenue, Valley Green, Bells Mill Road.

Cardamine impatiens. Bitter-cress. Bottomland. Rare. Bells Mill Road, Thomas Mill Road.

Cardamine pensylvanica. Wood cress, Pennsylvania bitter-cress. Deep hollows in woods, shaded ditches, etc. Local. Henry Avenue, Walnut Lane, Mt. Airy Avenue, Livezey Lane, Valley Green, Rex Avenue, Bells Mill Road.

Dentaria heterophylla (*Cardamine heterophylla*). Pepper-root, toothwort. Woods and thickets. Rare. Gorgas Lane.

Dentaria laciniata. (*Cardamine concatenata*). Cut-leaved toothwort. Rich woods. Scattered and locally abundant. Henry Avenue, Kitchen's Lane, Mt. Airy Avenue, Bells Mill Road.

Draba verna (*Erophila verna*). Whitlow-grass. Found sparingly in dry, open places in early spring.

Hesperis matronalis. Dame's-rocket. Established along trails and borders of woods. Both the purple and white flowered forms occur. Livezey Lane, Rex Avenue, Thomas Mill Road.

Lepidium virginicum. Wild pepper-grass. Dry, open situations, weedy. Henry Avenue, Carpenter's Woods, Livezey House, Valley Green.

Rorripa islandica (*R. palustris* ssp. *palustris*). Yellow cress. Ditches, wet, seepy slopes. Henry Avenue, Walnut Lane, Livezey Lane, west side below Valley Green.

Rorripa sylvestris. Creeping yellow-cress. Muddy stream banks and damp meadows. Occasional. Thorps Lane.

Sisymbrium altissimum. Tumble mustard. An occasional weed in waste places.

Sisymbrium officinale var. *leiocarpum*. Hedge mustard. An occasional weed in waste places.

Sisymbrium thalianum (*Arabidopsis thalianum*). Mouse-ear cress. Dry, open slopes and sandy clearings; early spring.

CRASSULACEAE, STONE-CROP FAMILY

Sedum sarmentosum. Live-for-ever. Sparingly escaped from cultivation, below Walnut Lane.

(Saxifragaceae)

Penthorum sediodes. Ditch stonecrop. Ditches and wet, muddy shores. Infrequent. Above Walnut Lane.

SAXIFRAGACEAE, SAXIFRAGE FAMILY

Chrysosplenium americanum. Golden saxifrage. Ditches, springheads, streams. Apparently uncommon. Below Bells Mill Road.

Heuchera americana. Alum-root. Wooded, often rocky slopes. Occasional.

Mitella diphylla. Miterwort. Rich to dry woods and thickets. Infrequent. Thomas Mill Road.

Saxifraga pensylvanica. Swamp saxifrage. Wet slopes, boggy thickets. Infrequent. In upper valley.

Saxifraga virginiensis. Early saxifrage. Dry to moist, rocky woods or shady slopes. Locally abundant. Henry Avenue, Bluestone Bridge.

(Hydrangeaceae)

Deutzia scabra. Deutzia. Cultivated and occasionally escaped to thickets, stream banks, etc. Cresheim Creek, Thomas Mill Road.

Hydrangea paniculata. Panicled hydrangea. Native of eastern Asia. Occasionally escaped to thickets. Walnut Lane, Cresheim Valley.

Hydrangea quercifolia. Oak-leaved hydrangea. Native of southeastern states. Cultivated and sparingly escaped. Cresheim Valley.

Philadelphus coronarius. Mock-orange. Occasional as an escape from cultivation. Henry Avenue, Mt. Airy Avenue, Livezey Lane, Harper's Meadow.

HAMAMELIDACEAE, WITCH-HAZEL FAMILY

Hamamelis virginiana. Fall-blooming witch-hazel. Common throughout. Bluestone Bridge, Walnut Lane, Kitchen's Lane, Mt. Airy Avenue, Cresheim Valley, Valley Green, Rex Avenue, Thomas Mill Road, Bells Mill Road, Harper's Meadow.

Liquidambar styraciflua. Sweet-gum. A tree of the Atlantic Coastal Plain, planted for its star-shaped leaves and brilliant autumn color. Hermit's Lane, Paper Mill Run.

PLATANACEAE, PLANE-TREE FAMILY

Platanus occidentalis. Buttonwood, sycamore. Common throughout. Henry Avenue, Bluestone Bridge, Walnut Lane, Mt. Airy Avenue, Cresheim Valley, Valley Green, Rex Avenue, Thomas Mill Road, Bells Mill Road.

ROSACEAE, ROSE FAMILY

Agrimonia gryposepala. Agrimony. Thickets and clearings. Frequent. Kitchen's Lane, Cresheim Valley, Harper's Meadow.

Agrimonia parviflora. Agrimony. Damp thickets, meadows, clearings. Common. Mt. Airy Avenue, Cresheim Valley, Bells Mill Road, Harper's Meadow.

Agrimonia pubescens (A. mollis). Downy agrimony. Woods and thickets. Occasional. Below Devil's Pool.

Amelanchier arborea. Service-berry. Infrequent on dry, wooded slopes. Kitchen's Lane, Hartwell Lane.

Crataegus. Hawthorn. A number of species of *Crataegus* have been found in the valley. However, this genus is extremely difficult, and no attempt is made here to differentiate the various kinds.

Duchesnea indica. Indian strawberry. Grassy clearings, waste ground, etc. Bluestone Bridge, Walnut Lane, Kitchen's Lane, Mt. Airy Avenue, Cresheim Valley, Bells Mill Road, Thorps Lane, Harper's Meadow.

Fragaria virginiana. Wild strawberry. Occasional on open slopes and in grassy clearings.

Geum canadense. Avens. Thickets and borders of woods. Cresheim Valley, Valley Green, Hartwell Avenue, Rex Avenue, Bells Mill Road, Harper's Meadow.

Gillenia trifoliata (Poteranthus trifoliatus). Bowman's-root. Collected in the valley around 1910 near Thorps Lane. Not seen in recent years. Should be sought for.

Physocarpus opulifolius. Ninebark. Thickets. Cresheim Valley, Hartwell Avenue.

Potentilla canadensis. Cinquefoil. Dry, open ground. Frequent. Henry Avenue, Bluestone Bridge, Walnut Lane, Mt. Airy Avenue, Bells Mill Road.

Potentilla norvegica. Three-leaf cinquefoil. Clearings and waste ground. Fairly frequent.

Potentilla recta. Sulfur cinquefoil. Dry fields and roadsides. Occasional.

Potentilla simplex. Old-field cinquefoil. Dry fields, clearings, roadsides. Fairly common throughout,especially along West Drive. Henry Avenue, Carpenter's Woods, Valley Green.

Prunus avium. Bird cherry, sweet cherry. Occasional as an escape. Hermit's Lane, Thomas Mill Road.

Prunus persica. Peach. Occasional as an escape.

Prunus serotina. Wild black cherry. Fairly common throughout. Hermit's Lane, Henry Avenue, Walnut Lane, Kitchen's Lane, Carpenter's Woods, Harper's Meadow.

Pyrus arbutifolia (*Aronia arbutifolia*). Red-fruited chokeberry. Occasional on dry slopes and in clearings.

Pyrus communis. Pear. Occasional as an escape.

Pyrus malus (*Malus pumila*). Apple. Occasional as an escape.

Pyrus melanocarpa (*Aronia melanocarpa*). Black-fruited chokeberry. Dry clearings and thickets. Occasional.

Rhodotypus kerrioides (*R. scandens*). Jetbead. Escape from cultivation. Carpenter's Woods, Cresheim Valley, Hartwell Avenue, Valley Green, Rex Avenue, Bells Mill Road.

Rosa carolina. Pasture Rose. Occasional in low thickets, borders of woods, etc. Springfield Avenue.

Rubus allegheniensis. Blackberry. Frequent in clearings, borders of woods, etc. Hermit's Lane, Bluestone Bridge, Kitchen's Lane, Devil's Pool, Cresheim Valley, Harper's Meadow.

Rubus baileyanus (R. flagellaris). Northern dewberry, trailing blackberry. Occasional in grassy clearings, open slopes, etc.

Rubus hispidus. Trailing raspberry. Thickets and damp ground. Walnut Lane.

Rubus laciniatus. Cut-leaved blackberry. Introduced from the Old World. Rare. Bluestone Bridge, Mt. Airy Avenue, Thomas Mill Road.

Rubus occidentalis. Black raspberry. Fairly frequent in thickets and on dry slopes. Hermit's Lane, Cresheim Valley, Thomas Mill Road, Bells Mill Road, Harper's Meadow.

Rubus odoratus. Purple-flowered raspberry. Scattered throughout. Thomas Mill Road.

Rubus phoenicolasius. Wineberry. An introduction from Asia. Fairly common. Henry Avenue, Walnut Lane, Carpenter's Woods, Livezey Lane, Cresheim Valley, Rex Avenue, Bells Mill Road, Harper's Meadow.

Spiraea latifolia. Meadow-sweet. Occasional on dry slopes.

LEGUMINOSAE, PEA FAMILY

(Caesalpiniaceae)

Cassia hebecarpa (*Senna hebacarpa*). Wild senna. Alluvial thickets. Rare. South of Rex Avenue, Thorps Lane.

Cassia nictitans (Chamaecrista nictitans). Wild sensitive-plant. Dry, sandy soil. Rare. Thomas Mill Road.

Cercis canadensis. Redbud, judas tree. Although originally native to the valley, most of the specimens seen today are the result of recent plantings. Hermit's Lane, Cresheim Creek, Rex Avenue, Thomas Mill Road.

Gleditsia triacanthos. Honey-locust. Planted here and there throughout the valley and occasionally naturalized.

Gymnocladus dioica. Kentucky coffee-tree. Native further south; possibly escaped from cultivation. Thomas Mill Road.

(Fabaceae)

Amorpha fruticosa. Lead plant, false indigo. Established at several localities. Hermit's Lane, Henry Avenue, Bluestone Bridge, Livezey house, Thomas Mill Road, Harper's Meadow.

Amphicarpa bracteata. Hog-peanut. Abundant in thickets and trailing over low vegetation. Bluestone Bridge, Walnut Lane, Mt. Airy Avenue, Livezey Lane, Cresheim Valley, Rex Avenue, Bells Mill Road, Harper's Meadow. Variety *comosa*, with more hairy stems, is known from Thorps Lane.

Crotalaria sagittalis. Rattlebox. Occasional in dry, sandy soil.

Desmodium canadense. Beggar's-tick. Thickets and dry, open ground. Occasional. Cresheim Valley, Thomas Mill Road, Bells Mill Road.

Desmodium canescens. Tick-trefoil. Dry clearings and meadows. Occasional.

Desmodium dillenii (*D. perplexum*). Tick-trefoil. Borders of dry woods and thickets. Infrequent. Walnut Lane, Cresheim Valley, Bells Mill Road.

Desmodium grandiflorum (*D. cuspidatum*). Tick-trefoil. Open woods, thickets and clearings. Occasional.

Desmodium laevigatum. Tick-trefoil, smooth tick-clover. Dry, open situations. Rare. Springfield Avenue.

Desmodium marilandicum. Tick-trefoil, Maryland tick-trefoil. Dry, open sandy woods and clearings. Rare. Hartwell Avenue.

Desmodium nudiflorum. Tick-trefoil, naked-flowered tick-trefoil. Clearings and borders of dry woods. Fairly frequent. Cresheim Valley, Thomas Mill Road, Bells Mill Road.

Desmodium paniculatum. Tick-trefoil. Dry thickets and clearings. Scattered throughout. Cresheim Valley.

Desmodium rigidum (*D. obtusum*). Tick-trefoil. Dry banks and open, sandy places. Rare. Thomas Mill Road.

Desmodium rotundifolium. Tick-trefoil. Occasional in open woods, thickets, and clearings. Hartwell Avenue.

Desmodium viridiflorum. Tick-trefoil, velvety tick-trefoil. Borders of woods, thickets, and dry, open situations. Infrequent. Springfield Avenue.

Lespedeza hirta. Bush-clover. Dry banks and clearings.Infrequent. Thomas Mill Road, Bells Mill Road.

Lespedeza intermedia. Bush-clover. Dry, open woods and thickets. Occasional. Thorp's Lane.

Lespedeza procumbens. Bush-clover. Dry woods and clearings. Occasional. Thorp's Lane.

Lespedeza violacea. Bush-clover. Dry, open ground. Occasional. Below Bells Mill Road.

Medicago lupulina. Black medick. Roadsides, clearings, waste ground.

Medicago sativa. Alfalfa, lucerne. An occasional weed in open ground, along trails, and in waste places.

Melilotus alba. White melilot. Occasional as a weed along trails and in clearings.

Melilotus officinalis. Yellow melilot. Occasional as a weed along trails and in waste ground.

Robinia pseudo-acacia. Black locust. Although not originally indigenous in this area, Black locust has been much planted and is now widely scattered. Hermit's Lane, Walnut Lane, Cresheim Valley.

Strophostyles helvola. Wild bean. Dry woods and clearings. Rare.

Tephrosia virginiana. Goat's-rue. Dry woods and clearings. Rare. Hartwell Avenue.

Trifolium agrarium (*T. aureum*). Yellow clover. Dry slopes and grassy clearings. Occasional. Bells Mill Road.

Trifolium hybridum. Alsike clover. Grassy clearings, roadsides. Frequent.

Trifolium pratense. Purple clover, red clover. Open fields and meadows. Common. Cresheim Valley.

Trifolium repens. White clover. Open fields and clearings. Common. Mt Airy Avenue.

Wisteria sinensis. Chinese wisteria. Native of Asia. Occasionally established, mouth of Paper Mill Run, Bluestone Bridge.

LINACEAE, FLAX FAMILY

Linum virginianum. Flax, slender yellow flax. Dry, open woods, clearings, and slopes. Apparently rare, seen only along bridle path south of Bells Mill Road.

OXALIDACEAE, WOOD SORREL FAMILY

Oxalis europaea (*O. stricta*). Yellow wood-sorrel. A common weed of dry, open slopes, roadsides, clearings, etc. Bluestone Bridge, Walnut Lane, Mt. Airy Avenue, Cresheim Valley, Rex Avenue.

Oxalis violacea. Violet wood-sorrel. Dry, wooded slopes. Rare. Not recently seen.

GERANIACEAE, CRANE'S BILL FAMILY

Erodium cicutarium. Storksbill, redstem filaree. Fields and waste places. Rare.

Geranium maculatum. Wild geranium, cranesbill. Common throughout in woods, thickets, and meadows. Kitchen's Lane, Cresheim Creek, Valley Green.

SIMARUBACEAE, QUASSIA FAMILY

Ailanthus altissima. Tree-of-heaven. Introduced from Asia and naturalized everywhere throughout the area. Henry Avenue, Walnut lane, Cresheim Valley, Livezey Lane.

EUPHORBIACEAE, SPURGE FAMILY

Acalypha rhombiodea. Three-seeded mercury. Moist hollows, roadsides, etc. Frequent.

Bluestone Bridge, Walnut Lane, Livezey Lane.

Acalypha virginica. Three-seeded mercury. Dry ground. Uncommon.

Euphorbia cyparissias. Cypress spurge. Introduced from Europe and naturalized in fields and clearings, Livezey Lane, Thomas Mill Road, Thorps Lane, Bells Mill Road, Harper's Meadow.

Euphorbia maculata (*Chamaesyce maculata*). Eyebane. Dry, open ground. Occasional.

Euphorbia supina (*Chamaesyce maculata*). Milk purslane. Roadsides, clearings, etc. Fairly frequent, especially around parking and picnic areas.

CALLITRICHACEAE, WATER-STARWORT FAMILY

Callitriche stagnalis. Water-chickweed. Occasional in pools and ditches. Henry Avenue, Walnut Lane, Cresheim Creek.

LIMNANTHACEAE, FALSE MERMAID FAMILY

Floerkea proserpinacoides. False-mermaid. Low, rich woods. Occasional. Early spring. Kitchen's Lane, Bells Mill Road, Harper's Meadow.

ANACARDIACEAE, CASHEW FAMILY

Rhus glabra. Smooth sumac. Dry thickets and borders of woods. Cresheim Valley, Thomas Mill Road.

Rhus radicans (*Toxicodendron radicans*). Poison-ivy.Thickets, open woods. Some forms shrubby, others trailing or highclimbing. Common throughout. Bluestone Bridge, Walnut Lane, Kitchen's Lane, Cresheim Valley, Thomas Mill Road, Bells Mill Road.

Rhus typhina. Staghorn sumac. Thickets and dry clearings. Occasional.

CELASTRACEAE, STAFF-TREE FAMILY

Celastrus orbiculatus. Bittersweet. Introduced from Asia; cultivated and spreading rapidly in our area. Bluestone Bridge, Livezey Lane, Devil's Pool, Thomas Mill Road. (This species has rounder leaves than the native bittersweet, which follows).

Celastrus scandens. Bittersweet. Woods, thickets, stream banks. Fairly common. Monastery, Carpenter's Woods, Cresheim Valley, Thomas Mill Road, Bells Mill Road.

Euonymus alatus. Spindle-tree. Introduced from Asia and occasional as an escape from cultivation, as above Walnut Lane, and along Rex Avenue.

Euonymus americanus. Strawberry-bush. Rich woods and thickets. Apparently not common. Henry Avenue, Cresheim Valley, Rex Avenue, above Thomas Mill Road, Bells Mill Road.

Euonymus europaeus. European spindle-tree. Introduced from Europe and sparingly escaped from cultivation. Thorps Lane.

STAPHYLACEAE, BLADDERNUT FAMILY

Staphylea trifolia. Rich woods and thickets, mostly in bottomland. Fairly frequent throughout. Henry Avenue, Walnut Lane, Thomas Mill Road, Bells Mill Road, Harper's Meadow.

ACERACEAE, MAPLE FAMILY

Acer negundo. Ash-leaved maple, box-elder. Steam banks and low ground. Common throughout. Mouth, Henry Avenue, Bluestone Bridge, Walnut Lane, Kitchen's Lane, Livezey Lane, Cresheim Valley, Thomas Mill Road, Bells Mill Road, Harper's Meadow.

Acer platanoides. Norway maple. Cultivated and occasionally escaped. Livezey Lane, Cresheim Valley, Harper's Meadow.

Acer pseudo-platanus. Sycamore maple. Sparingly escaped from cultivation. Walnut Lane, Cresheim Valley.

Acer rubrum. Red maple, swamp maple. Low, usually moist ground. Fairly frequent throughout. Walnut Lane, Carpenter's Woods, Cresheim Valley, Valley Green, Rex Avenue.

Acer saccharinum. Silver maple. Rich woods of bottomland. Occasional. Kitchen's Lane, Cresheim Valley, Harper's Meadow.

Acer saccharum. Sugar maple. Dry slopes. Occasional. Hermit's Lane.

Acer spicatum. Mountain maple. Dry, open woods and thickets. Apparently rare. Collected in the valley in 1924, but no locality given.

SAPINDACEAE, SOAPBERRY FAMILY

Cardiospermum halicababum. Balloon-vine. Native of tropical America. Established around spring on east bank, just below Bells Mill Road.

HIPPOCASTANACEAE, BUCKEYE FAMILY

Aesculus glabra. Ohio buckeye. Cultivated and occasionally escaped. Henry Avenue, Carpenter's Woods, south of Bells Mill Road, Harper's Meadow.

Aesculus hippocastanum. Horse-chestnut. Native of Europe. Widely planted in our area and sparingly escaped from cultivation. Near Leverington Street.

BALSAMINACEAE, TOUCH-ME-NOT FAMILY

Impatiens biflora (*I. capensis*). Orange jewelweed. Low, rich ground. Common throughout. Bluestone Bridge, Walnut Lane, Kitchen's Lane, Cresheim Valley, Valley Green, Rex Avenue, Thomas Mill Road, Bells Mill Road, Harper's Meadow.

Impatiens pallida. Yellow jewelweed. Low, rich ground. Common throughout. Walnut Lane, Devil's Pool, Cresheim Valley, Valley Green, Rex Avenue, Thomas Mill Road, Bells Mill Road, Harper's Meadow.

RHAMNACEAE, BUCKTHORN FAMILY

Ceanothus americanus. New Jersey tea. Dry ground. Collected somewhere in the valley in 1889, but not seen in recent years.

VITACEAE, VINE FAMILY

Ampelopsis arborea. Pepper-vine. Swampy woods. Cultivated in our area and sparingly escaped from gardens.

Parthenocissus quinquefolia. Virginia-creeper. Woods and thickets. Frequent. Hermit's Lane, Walnut Lane, Cresheim Valley, Valley Green, Rex Avenue, Thomas Mill Road, Bells Mill Road, Harper's Meadow.

Vitis aestivalis. Summer grape. Dry woods and thickets. Infrequent. Hermit's Lane, Thomas Mill Road, below Bells Mill Road.

Vitis labrusca. Fox grape. Woods and thickets. Infrequent. Cresheim Valley.

Vitis riparia. River-bank grape. Thickets and stream banks. Occasional throughout. Bluestone Bridge, Walnut Lane, Rex Avenue.

Vitis vulpina. Frost grape. Thickets and bottomland. The commonest grape in the valley.

Hermit's Lane, Henry Avenue, Walnut Lane, Monastery, Mt. Airy Avenue, Cresheim Valley, Bells Mill Road, Harper's Meadow.

TILIACEAE, LINDEN FAMILY

Tilia americana. Basswood. Rich woods. Common. Livezey Lane, Cresheim Valley, Thomas Mill Road, Bells Mill Road, Harper's Meadow.

MALVACEAE, MALLOW FAMILY

Althaea rosea (*Alcea rosea*). Hollyhock. Escaped from cultivation and occasionally persistent in waste ground.

Hibiscus syriacus. Rose-of-sharon. Native of Asia. Cultivated and sparingly escaped. Carpenter's Woods.

Malva neglecta (*M. rotundifolia*). Cheeses. Occasional as a weed near parking lots and picnic areas.

HYPERICACEAE, ST.-JOHN'S-WORT FAMILY
(Clusiaceae)

Ascyrum hypericoides (*Hypericum hypericoides*). St.-Andrew's- cross. Dry sandy soil. Rare; known only from near Thomas Mill Road.

Hypericum gentianoides. Orange-grass, pineweed. Sandy or rocky slopes. Rare. Hartwell Avenue.

Hypericum mutilum. St.-John's-wort. Low, damp ground. Frequent in ditches along drive, below Valley Green, near Germantown Avenue, Chestnut Hill.

Hypericum perforatum, Common St.-John's-wort. Dry fields, clearings, etc. Fairly frequent in open, grassy situations.

Hypericum punctatum. St.-John's-wort. Low, usually damp ground. Occasional. Above Thomas Mill Road, Bells Mill Road.

CISTACEAE, ROCKROSE FAMILY

Helianthemum canadense. Frostweed, rock-rose. Dry, open woods. Rare. Bells Mill Road.

Lechea minor. Pinweed. Dry woods and open slopes. Rare. Springfield Avenue.

Lechea racemulosa. Pinweed. Open, sandy woods and slopes. Rare. Carpenter's Woods, Hartwell Avenue.

VIOLACEAE, VIOLET FAMILY

Viola blanda. Sweet white violet. Rich woods, damp thickets, and rocky slopes. Frequent. Bluestone Bridge, Walnut Lane, Allens Lane.

Viola conspersa. Dog violet. Damp woods, thickets, and shaded slopes. Occasional. Allens Lane.

Viola cucullata. Swamp blue violet. Springheads, seepy slopes, moist depressions. Frequent. Cresheim Creek, Mt. Airy Avenue, Valley Green, Rex Avenue, Bells Mill Road.

Viola hirsutula. Hairy blue violet. Moist to dry wooded slopes. Infrequent. Allens Lane.

Viola incognita (*V. blanda*). Wet to dry woods, thickets, and clearings. Rare. Near Indian Rock.

Viola pallens (*V. macloskeyi* ssp. *pallens*). Wet or springy woods, thickets, or slopes. Occasional. Thomas Mill Road.

Viola palmata. Early blue violet. Rich woods and slopes. Infrequent.

Viola papilionacea (*V. sororia* var. *sororia*). Common blue violet. Meadows, clearings, open banks, etc. Fairly common throughout. Henry Avenue, Walnut Lane, Cresheim Valley.

Viola pedata. Birds-foot violet. Dry, sterile soil. Rare, known only from along Bells Mill Road, west of the creek. Ours is the variety *lineariloba* with all the petals lilac-purple. Bells Mill Road.

Viola pensylvanica (V. eriocarpa). Smooth yellow violet. Rich woods and thickets. Common throughout. Henry Avenue, Bluestone Bridge, Kitchen's Lane, Bells Mill Road.

Viola primulifolia. Primrose-leaved white violet. Dry clearings. Carpenter's Woods.

Viola pubescens. Hairy yellow violet. Rich woods and thickets. Somewhat restricted. Henry Avenue.

Viola rotundifolia. Early yellow violet, round-leaved yellow violet. Extremely common on moist to dry, wooded slopes, especially under hemlock. Walnut Lane, Mt. Airy Avenue, Valley Green, Rex Avenue, Thomas Mill Road, Bells Mill Road.

Viola sagittata var. *ovata* (*V. fimbriatula*). Arrow-leaved violet. Dry woods and clearings. Occasional. Bells Mill Road.

Viola sororia. Common blue violet. Open woods, moist slopes. Frequent throughout. Henry Avenue, Walnut Lane, Rex Avenue.

Viola striata. Striped white violet. Rich woods and thickets. Occasional. Cresheim Creek.

Viola triloba (*V. palmata*). (Early blue violet). Open thickets, clearings, dry slopes, etc. Infrequent. Near Devil's Pool.

ONAGRACEAE, EVENING-PRIMROSE FAMILY

Circaea quadrisulcata var. *canadensis.* (*C. lutetiana* ssp. *canadensis*). Enchanter's-nightshade. Rich woods, thickets, and bottomland, extremely common throughout. Native. Henry Avenue, Bluestone Bridge, Walnut Lane, Livezey Lane, Cresheim Valley, Valley Green, Rex Avenue, Thomas Mill Road, Bells Mill Road, Harper's Meadow.

Epilobium angustifolium. Great willow-herb. fireweed. Recent clearings and waste grounds. Infrequent. Hartwell Avenue.

Epilobium coloratum. Tawny willow-herb. Low, damp ground. Rare.

Epilobium densum (E. strictum). Willow-herb. Occasional on sandy and gravelly shores.

Gaura biennis. Biennial velvet-weed. Thickets, bottomlands, damp shores. Rare. Hartwell Avenue.

Ludwigia alternifolia. Seed-box. Low, damp ground, muddy shores. Infrequent. Cresheim Valley, Bells Mill Road.

Ludwigia palustris. Water-purslane. Wet, muddy, and gravelly shores. Common. Mouth of creek, Henry Avenue, Walnut Lane, Mt. Airy Avenue, Livezey Lane, Thomas Mill Road.

Oenothera biennis. Common evening-primrose. Meadows, clearings, waste ground, disturbed soils. Occasional. Henry Avenue, Bluestone Bridge, Walnut Lane, Kitchen's Lane, Valley Green, Harper's Meadow.

Oenothera perennis (*O. pumila*). Sundrops. Damp to dry open ground. Infrequent.

ARALIACEAE, GINSENG FAMILY

Acanthopanax sieboldianus. Acanthopanax. Introduced from Asia and occasionally escaped from cultivation, as near Harper's Meadow.

Aralia chinensis. Chinese angelica or Hercules'-club. This large Asiatic shrub with prickly stems and leaves is established and apparently spreading in the valley. It is especially common near Walnut Lane Bridge, but occurs also near near Bluestone Bridge, near

Valley Green, at Thomas Mill Road.

Aralia nudicaulis. Wild sarsparilla. Dry woods and shady slopes. Scattered throughout. Henry Avenue, Walnut Lane, Kitchen's Lane, Cresheim Valley, Rex Avenue, Thomas Mill Road.

Aralia racemosa. Spikenard. Rich woods and damp slopes. Very abundant at foot of wet cliffs along Drive between Valley Green and Thomas Mill Road. Also Bluestone Bridge, Walnut Lane, Kitchen's Lane, Livezey lane, Cresheim Valley, Bells Mill Road.

Aralia spinosa, Hercules'-club. This is the native American species of Hercules'-club which has leaves less prickly than *A. chinensis*. It is scattered locally in the upper valley. Hermit's Lane, Kitchen's Lane, Thomas Mill Road.

Hedera helix. English Ivy. Abundantly planted on dwellings and stonework, and occasionally spreading in shaded situations, often growing on tree trunks. Henry Avenue, Walnut Lane, Cresheim Creek.

Panax trifolius. Dwarf American ginseng. Rich woods. Rare and local. Henry Avenue, Walnut Lane, Kitchen's Lane, Mt. Airy Avenue, ravine above Thomas Mill Road.

UMBELLIFERAE, PARSLEY FAMILY
(Apiaceae)

Aegopodium podagraria. Goutweed. Naturalized from Europe and abundantly established at a number of localities. Along drive below Henry Avenue, Kitchen's Lane, Mt. Airy Avenue, Cresheim Creek, Valley Green, Thomas Mill Road.

Cicuta maculata. Spotted cowbane, water-hemlock. Swales, bottomlands. Occasional. Cresheim Valley.

Cryptotaenia canadensis. Honewort, wild chervil. Dominant in damp ground along drives and trails throughout. Bluestone Bridge, Walnut Lane, Kitchen's Lane, Cresheim Valley, Valley Green, Rex Avenue, Bells Mill Road, Harper's Meadow.

Daucus carota. Wild carrot, Queen-Anne's-lace. Meadows, grassy clearings, etc. Locally abundant throughout. Livezey Lane, Cresheim Valley.

Heracleum maximum (*H. lanatum*). Cow-parsnip. Swales and low, damp woods. Occasional. Walnut Lane, Valley Green, near Harper's Meadow.

Hydrocotyle americana. Water penny-wort. Damp woods and wet depressions. Occasional in ditches, e.g: below Bells Mill Road, Wise's Mill Road.

Osmorhiza claytonii. Sweet-cicely, wild-licorice. Woods and shaded slopes. Frequent throughout. Cresheim Valley, Thomas Mill Road.

Osmorhiza longistylis. Anise-root. Rich woods and alluvial thickets. Less abundant than *O. claytoni*. Bluestone Bridge, Kitchen's Lane, Valley Green, Bells Mill Road.

Oxypolis rigidior. Cowbane. Wet woods and swamps. Rare. Thorp's Lane, near Harper's Meadow.

Pastinaca sativa. Parsnip. Clearings and waste ground. Sporadic. Near Harper's Meadow.

Sanicula canadensis. Black snake-root. Dry, open woods and shaded slopes. Abundant throughout. Bluestone Bridge, Walnut Lane, Kitchen's Lane, Mt. Airy Avenue, Cresheim Valley, Thomas Mill Road, Harper's Meadow.

Sanicula gregaria (*S. odorata*). Black snake-root. Rich woods. Infrequent. Mt. Airy Avenue.

Sanicula trifoliata. Black snake-root. Occasional in rich woods. Walnut Lane, Mt. Airy Avenue, Gorgas Lane, Valley Green.

Thaspium barbinode. Meadow-parsnip. Abundant in rich woods and thickets. Walnut Lane, Kitchen's Lane, Rex Avenue, Thomas Mill Road, Bells Mill Road.

Thaspium trifoliatum. Meadow-parsnip. Woods and shaded slopes. Rare. Thorps Lane.

CORNACEAE, DOGWOOD FAMILY

Cornus alternifolia. Alternate-leaved dogwood. Dry woods and rocky slopes. Rare and local. Walnut Lane, Allens Lane, Valley Green.

Cornus amomum. Silky cornel. Moist to dry woods and thickets. Infrequent. Carpenter's Woods, Livezey Lane, Cresheim Valley, Harper's Meadow.

Cornus florida. Common dogwood. Both planted and native. Frequent. Walnut Lane, Carpenter's Woods, Thomas Mill Road, Bells Mill Road.

Cornus racemosa. Panicled dogwood. Woods and thickets. Occasional. Henry Avenue, Kitchen's Lane.

(Nyssaceae)

Nyssa sylvatica. Sour-gum. Moist to dry woods. Fairly common. Hermit's Lane, Walnut Lane, Carpenter's Woods, Livezey Lane, Valley Green, Thomas Mill Road, Bells Mill Road.

PYROLACEAE, WINTERGREEN FAMILY

Chimaphila maculata. Striped pipsissewa, spotted wintergreen. Dry, usually acid woods and slopes. Rare and local. Carpenter's Woods, Valley Green, Bells Mill Road.

Pyrola elliptica. Shinleaf. Dry to moist woods. Occasional. Thorps Lane.

Pyrola secunda (*Orthilia secunda*). One-sided pyrola. Dry to moist woods. Rare.

Pyrola virens (*P. chlorantha*). Wintergreen. Dry, open woods and clearings. Rare.

(Monotropaceae)

Monotropa hypopithys. Pine-sap, false beechdrops. Woodland humus. Infrequent and seasonal. Rex Avenue.

Monotropa uniflora. Indian-pipe. Woodland humus. Occasional. South of Rex Avenue, Walnut Lane.

ERICACEAE, HEATH FAMILY

Epigaea repens. Trailing arbutus. Dry, usually acid woods and rocky slopes. Less common than formerly, but still locally abundant, especially near the crests of the Valley. Walnut Lane, Carpenter's Woods, Cresheim Valley, Valley Green, Bells Mill Road.

Gaultheria procumbens. Wintergreen, teaberry, checkerberry. Dry woods and clearings. Collected many years ago, with no locality given. Probably no longer present.

Gaylussacia baccata. Black huckleberry. Dry woods and thickets. Infrequent. Carpenter's Woods, Bells Mill Road.

Gaylussacia frondosa. Dangleberry. Dry woods, shaded slopes, and clearings. Infrequent.

Kalmia angustifolia. Sheep laurel, lambkill. Dry or moist, usually acid soil. Rare. Hartwell Avenue.

Kalmia latifolia. Mountain laurel, calico bush. Both planted and native. Dry, acid woods and slopes throughout. Walnut Lane, Carpenter's Woods, Hartwell Avenue, Rex Avenue, below Bells Mill Road.

Lyonia ligustrina. Maleberry. Dry thickets and clearings. Rare. Cresheim Valley.

Lyonia mariana. Stagger-bush. Dry, sandy soil. Rare. Hartwell Avenue.

Rhododendron maximum. Great-laurel, rosebay. Widely planted throughout the valley, but not occuring as a native.

Rhododendron nudiflorum (*R. periclymenoides*). Pinxter-flower. Dry woods and shaded slopes. Locally abundant. Carpenter's Woods, Livezey Lane, Cresheim Valley, Valley Green, Bells Mill Road.

Vaccinium angustifolium. Lowbush blueberry. Dry, sterile slopes. Infrequent. Thomas Mill Road.

Vaccinium corymbosum. Highbush blueberry. Low woods and moist thickets. Occasional. Carpenter's Woods, Cresheim Valley, Bells Mill Road.

Vaccinium stamineum. Deerberry, squaw-huckleberry. Dry woods, thickets, and clearings. Rare. Walnut Lane, Kitchen's Lane, Carpenter's Woods, Bells Mill Road.

Vaccinium vacillans (*V. pallidum*). Early sweet blueberry. Dry, open woods, thickets, and clearings. Rare. Hermit's Lane, Walnut Lane, Kitchen's Lane, Carpenter's Woods, Valley Green, Thomas Mill Road, Bells Mill Road.

PRIMULACEAE, PRIMROSE FAMILY

Lysimachia ciliata. Fringed loosestrife. Low, moist ground. Occasional. Bluestone Bridge, Livezey Lane.

Lysimachia nummularia. Moneywort. Damp roadsides, shores, and springheads. Fairly common throughout. Livezey Lane.

Lysimachia quadrifolia. Whorled loosestrife. Dry, open woods, thickets, and clearings. Frequent throughout, especially on upper slopes. Walnut Lane, Mt. Airy Avenue.

OLEACEAE, OLIVE FAMILY

Fraxinus americana. White ash. Rich woods. Common throughout. Henry Avenue, Walnut Lane, Kitchen's Lane, Carpenter's Woods, Cresheim Valley, Rex Avenue, Thomas Mill Road, Bells Mill Road.

Fraxinus pennsylvanica. Green ash. Rich woods. Rare. Collected in the 1920's, no locality given.

Ligustrum obtusifolium. Japanese privet, Ibota privet. Native of Asia. Frequent as an escape. Bluestone Bridge, Rex Avenue, Bells Mill Road, Harper's Meadow.

Ligustrum vulgare. Common privet. Native of Europe. Frequent as an escape. Walnut Lane, Cresheim Valley, Thomas Mill Road, Bells Mill Road, Harper's Meadow.

GENTIANACEAE, GENTIAN FAMILY

Bartonia virginica. Bartonia. Wet, acid hollows. Rare. Hartwell Avenue.

Gentiana clausa. Closed gentian, bottle gentian. Wet thickets, stream banks. Infrequent. Livezey Lane.

Gentiana crinita (*Gentianopsis crinata*). Fringed Gentian. Meadows, open slopes, etc. Collected in the valley many years ago. Not seen recently.

APOCYNACEAE, DOGBANE FAMILY

Apocynum androsaemifolium. Spreading dogbane. Dry, open thickets and clearings. Occasional. Near Harper's Meadow.

Apocynum cannabinum. Indian Hemp. Thickets and open ground. Infrequent. Walnut Lane.

Vinca minor. Common periwinkle, myrtle. Native of Europe. Widely established in borders of woods, roadsides, etc. Hermit's Lane, Henry Avenue, Cresheim Valley, Thomas Mill

Road, Bells Mill Road.

ASCLEPIADACEAE, MILKWEED FAMILY

Asclepias exaltata. Poke milkweed. Occasional in rich woods and clearings. Thorps Lane.

Asclepias incarnata. Swamp milkweed. Swamps and wet thickets. Occasional. Walnut Lane, Kitchen's Lane, Thorps Lane.

Asclepias quadrifolia. Whorled milkweed. Woods and thickets. Occasional.

Asclepias syriaca. Common milkweed. Thickets, open banks, clearings, etc. Scattered throughout. Henry Avenue, Cresheim Valley, Thomas Mill Road.

Cynanchum nigrum (*Vincetoxicum nigrum*). Black swallow-wort. This twining vine, with milkweed-like flowers was collected in the early 1900's in Cresheim Valley near Mermaid Lane. Not seen in recent years.

Gonolobus obliquus (*Matelea obliqua*). Angle-pod. Thickets and borders of woods. Rare.

CONVOLVULACEAE, MORNING GLORY FAMILY

Convolvulus sepium (*Calystegium silvatica* ssp. *fraterniflora*). Hedge bindweed. Thickets, open banks, waste ground, etc. Sporadic throughout. Walnut Lane.

Ipomoea hederaceae. Morning-glory. Thickets and clearings. Occasional. Bells Mill Road.

Ipomoea pandurata. Wild potato-vine. Dry, open ground. Rare. Above Walnut Lane, Hartwell Avenue.

(Cuscutaceae)

Cuscuta gronovii. Dodder, love vine. Parasitic on herbaceous vegetation. Occasional throughout. Henry Avenue, Kitchen's Lane, Cresheim Valley, Valley Green, Livezey Lane, Harper's Meadow.

POLEMONIACEAE, PHLOX FAMILY

Phlox paniculata. Garden phlox. A frequent escape in the valley. Harper's Meadow.

Polemonium reptans. Jacob's-ladder. Rich woods and bottomland. Frequent. Walnut Lane, Kitchen's Lane, Valley Green, Rex Avenue, Thomas Mill Road, Bells Mill Road.

HYDROPHYLLACEAE, WATER-LEAF FAMILY

Hydrophyllum virginianum. Water-leaf. Rich woods and bottomland. Occasional. Henry Avenue, Walnut Lane, Bluestone Bridge, Kitchen's Lane, Mt. Airy Avenue, Livezey Lane, Valley Green, Thomas Mill Road, above Bells Mill Road, Harper's Meadow.

BORAGINACEAE, BORAGE FAMILY

Hackelia virginiana (*Lappula virginiana*). Stickseed, beggar's-lice. Woods and thickets. Occasional. Thomas Mill Road, Thorps Lane.

Lithospermum arvense (*Buglossoides arvense*). Corn gromwell. An occasional weed of fields and roadsides.

Mertensia virginica. Bluebells, Virginia cowslip. Both native and planted. Occasional. Harper's Meadow.

Myosotis laxa. Forget-me-not. Moist to dry open ground. Infrequent. Cresheim Creek.

Myosotis scorpioides. True forget-me-not. Stream borders and ditches. Occasional throughout. Henry Avenue, Bluestone Bridge, Walnut Lane, Kitchen's Lane, Livezey Lane, Rex Avenue, Harper's Meadow.

PHRYMACEAE, LOPSEED FAMILY
(Verbenaceae)

Phryma leptostachya. Lopseed. Rich woods. Fairly frequent throughout. Above Thorps Lane.

VERBENACEAE, VERVAIN FAMILY

Verbena urticifolia. White vervain. Thickets and borders of woods. Frequent. Henry Avenue, Walnut Lane, Livezey Lane, Thomas Mill Road, Bells Mill Road, Harper's Meadow.

LABIATAE, MINT FAMILY
(Lamiaceae)

Agastache nepetoides. Giant hyssop. Rich thickets and borders of woods.Infrequent. Thorps Lane.

Agastache scrophulariifolia. Giant hyssop. Rich woods and thickets. Infrequent. Collected in 1874, not recently seen.

Collinsonia canadensis. Horse-balm, richweed, stoneroot. Rich woods and thickets. Common. Henry Avenue, Bluestone Bridge, Walnut Lane, Mt. Airy Avenue, Livezey Lane, Cresheim Creek, Rex Avenue, Thomas Mill Road.

Cunila origanoides. American dittany, stone-mint. Dry, open woods and clearings. Infrequent. Thorps Lane.

Hedeoma pulegioides. Mock pennyroyal. Dry woods and thickets. Fairly frequent.

Lamium amplexicaule. Dead-nettle. Occasional as a weed in clearings and waste ground.

Lamium pupureum. Purple dead-nettle. Occasional as a roadside weed. Cresheim Creek, Harper's Meadow.

Leonurus cardiaca. Motherwort. An occasional weed near dwellings. Livezey Lane, Cresheim Valley.

Lycopus americanus. Water-horehound. Low, wet ground. Sporadic. Below Henry Avenue.

Lycopus uniflorus. Water-horehound. Low ground, ditches, etc. Fairly frequent. Bluestone Bridge, Walnut Lane, Rex Avenue, Bells Mill Road.

Lycopus virginicus. Water-horehound. Rich, moist soil. Occasional. Valley Green.

Mentha arvensis. Common mint. Damp, open situations. Occasional. Walnut Lane, Thorps Lane.

Mentha piperita. Peppermint. Low, wet ground. Infrequent. Bells Mill Road.

Mentha spicata. Spearmint. Wet depressions and ditches. Rare.

Monarda clinopodia. Wild bergamot. Moist thickets and stream banks. Rare. Walnut Lane, Thorps Lane.

Monarda didyma. Oswego-tea, bee-balm. Rich woods and bottomland. Rare. Not seen in recent years.

Monarda fistulosa. Wild bergamot. Dry woods and thickets. Occasional. Leverington Street, Bells Mill Road.

Nepeta cataria. Catnip. Occasional as a weed of roadsides and waste places. Bells Mill Road.

Nepeta hederacea (*Glechoma hederacea*). Ground ivy. Gill-over-the-ground. Roadsides and damp, shaded places. Common. Henry Avenue, Bluestone Bridge, Walnut Lane, Kitchen's Lane, Livezey Lane, Valley Green, Rex Avenue, Bells Mill Road, Harper's Meadow.

Origanum vulgare. Wild marjoram. Roadsides, old fields, and clearings. Rare. Allens Lane.

Perilla frutescens. Perilla. Introduced from Asia. Clearings and alluvial shores. Infrequent.

Henry Avenue.

Prunella vulgaris. Self-heal, heal-all. Open woods, thickets, roadsides, grassy places, etc. Ours is mostly the variety *lanceolata* , with leaves about twice as long as broad. Frequent throughout. Bluestone Bridge, Kitchen's Lane, Cresheim Valley, Valley Green, Thomas Mill Road, Harper's Meadow.

Pycnanthemum verticillatum. Mountain mint. Dry to moist thickets and clearings. Occasional.

Pycnanthemum virginianum. Mountain mint. Dry to wet thickets, meadows, etc. Occasional.

Salvia lyrata. Lyre-leaved sage. Open woods, clearings, roadsides. Infrequent. Bluestone Bridge.

Satureja vulgaris (*Clinopodium vulgare*). Basil. Dry, open fields, clearings, disturbed ground, etc. Occasional around parking and picnic areas.

Scutellaria elliptica. Hairy skullcap. Dry woods and thickets. Rare. Thorps Lane.

Teucrium canadense var. *virginicum*. Wood-sage. Damp thickets and meadows. Rare.

Trichostema dichotomum. Bluecurls. Dry, open soil. Occasional. Thomas Mill Road.

SOLANACEAE, NIGHTSHADE FAMILY

Lycium halimifolium (*L. barbarum*). Matrimony vine. Occasional as an escape to recent clearings and banks. Common between Henry Avenue and Reading R R. bridge, Cresheim Creek.

Physalis subglabrata. Ground cherry. Fields, roadsides, waste places. Thomas Mill Road, Harper's Meadow.

Solanum americanum (*S. nigrum*). Common nightshade. Roadsides, waste places, etc. Infrequent. Above Walnut Lane, Mt. Airy Avenue.

Solanum carolinense. Horse-nettle. An obnoxious weed in meadows, clearings, etc. Occasional. Mouth of creek, Hermit's Lane, Kitchen's Lane.

Solanum dulcamara. Climbing nightshade, bittersweet. Thickets and clearings. Occasional. Henry Avenue, Walnut Lane, Carpenter's Woods, Livezey Lane, Cresheim Valley, Valley Green, Rex Avenue.

SCROPHULARIACEAE, FIGWORT FAMILY

Aureolaria pedicularis. Fern-leaved false-foxglove. Rich to dry woods. Rare. Thorps Lane.

Aureolaria virginica. Downy false-foxglove. Dry woods and clearings. Rare. Thorps Lane.

Chelone glabra. Turtle head. Wet thickets, bottomland. Occasional. Bluestone Bridge, Walnut Lane, Valley Green, Harper's Meadow.

Cymbalaria muralis. Kenilworth-ivy. Occasional on old walls or the stonework of bridges.

Gerardia tenuifolia (*Agalinis tenuifolia*). Slender gerardia. Dry, open situations. Rare. Thorps Lane.

Gratiola neglecta. Hedge-hyssop. Wet or muddy places. Rare.

Linaria vulgaris. Yellow toadflax, butter-and-eggs. Meadows, roadsides, waste ground. Occasional throughout.

Lindernia dubia. False pimpernel. Stream shores and damp, muddy places. Rare.

Mazus japonicus (*M. pumilus*). Japanese mazus. Native of Asia, cultivated in lawns and gardens, and escaped to grassy fields and wet shores. Livezey Lane.

Mazus reptans (*M. miguelii*). Creeping mazus. Sand and gravel shores, escaped from cultivation. Rare. Henry Avenue.

Melampyrum lineare. Cow wheat. Dry woods and shaded slopes. Rare. Known only from steep, rocky bank along south side of Thomas Mill Road.

Mimulus alatus. Monkey-flower. Low, wet ground. Rare. Wise's Mill Road.

Mimulus ringens. Monkey-flower. Stream shores and wet meadows. Occasional. Livezey Lane, Wise's Mill Road.

Pedicularis canadensis. Wood-betony, lousewort. Moist to dry woods and thickets. Occasional in upper portion of valley. Thorps Lane.

Penstemon hirsutus. Beard-tongue. Dry, usually rocky woods and slopes. Occasional.

Scrophularia lanceolata. Figwort. Thickets and borders of woods. Infrequent.

Scrophularia marilandica. Figwort. Carpenter's Square. Rich woods and thickets. Occasional. Gypsy Lane, Walnut Lane, Kitchen's Lane, Livezey Lane, Harper's Meadow.

Verbascum blattaria. Moth mullein. An occasional weed of fields and clearings. Henry Avenue, Harper's Meadow.

Verbascum lychnitis. White mullein. clearings, waste places. Rare. Livezey Lane.

Verbascum thapsus. Common mullein. Fields, waste places, roadsides. Occasional. Harper's Meadow.

Veronica hederaefolia. Ivy-leaved speedwell. Occasional in clearings. Henry Avenue, Kitchen's Lane, Valley Green, Rex Avenue.

Veronica officinalis. Common speedwell. Dry woods, thickets, and clearings. Frequent. Valley Green, Rex Avenue, Harper's Meadow.

Veronica peregrina. Neckweed. Damp, open places, roadsides. Occasional. Rex Avenue.

Veronica serpyllifolia. Thyme-leaved speedwell. Meadows and picnic areas. Occasional.

BIGNONIACEAE, BIGNONIA FAMILY

Catalpa bignonioides. Catalpa, Indian-bean. Cultivated and escaped or naturalized throughout. Henry Avenue, Bluestone Bridge, Kitchen's Lane, Leverington Street, Cresheim Valley, Rex Avenue.

Paulownia tomentosa. Princess-tree. Cultivated, widely escaped and naturalized, native of Asia. Henry Avenue, Bluestone Bridge, Walnut Lane, Kitchen's Lane, Carpenter's Woods, Mt. Airy Avenue, Devil's Pool, Cresheim Valley, Rex Avenue, Bells Mill Road.

OROBANCHACEAE, BROOM-RAPE FAMILY

Conopholis americana. Squaw-root. Parasitic, mostly on various oaks. Sporadic. Not found in recent years.

Epifagus virginiana. Beech-drops. Parasitic on the beech tree. Common throughout. Hermit's Lane, Bluestone Bridge, Walnut Lane, Mt. Airy Avenue, Cresheim Valley, Rex Avenue, Bells Mill Road.

Orobanchae uniflora. One-flowered cancer-root. Parasitic on various herbaceous plants. Occasional.

PLANTAGINACEAE, PLANTAIN FAMILY

Plantago lanceolata. Rib-grass, buckhorn. A common weed of roadsides, fields, clearings, and disturbed soil.

Plantago major. Whiteman's foot. Roadsides, open ground. Occasional.

Plantago rugelii. Rugel's plantain. Same situations as *P.lanceolata* and *P. major*, but far more abundant. Walnut Lane, Livezey Lane.

RUBIACEAE, MADDER FAMILY

Cephalanthus occidentalis. Buttonbush. Damp thickets. Rare. Henry Avenue, above Walnut Lane, Livezey Lane.

Galium aparine. Cleavers. Woods, thickets, clearings. Fairly abundant. Kitchen's Lane, Cresheim Creek.

Galium asprellum. Bedstraw. Low, moist, open or shaded ground. Occasional. Walnut Lane, Harper's Meadow.

Galium circaezans. Wild licorice. Rich to dry woods. Fairly abundant.

Galium triflorum. Bedstraw. Rich woods. Locally abundant. Kitchen's Lane, Rex Avenue, Bells Mill Road.

Houstonia caerulea (*Hedyotis caerulea*). Bluets, Quaker-ladies, innocence. Open woods, thickets, and grassy clearings. Locally abundant. Hermit's Lane, Walnut Lane, Carpenter's Woods, Bells Mill Road.

Mitchella repens. Partridge-berry. Dry to moist woods. Common throughout. Walnut Lane, Kitchen's Lane, Carpenter's Woods, Mt. Airy Avenue, Cresheim Valley, Valley Green, Rex Avenue, Thomas Mill Road, Bells Mill Road.

CAPRIFOLIACEAE, HONEYSUCKLE FAMILY

Diervilla lonicera. Bush-honeysuckle. Dry woods and clearings. Rare and local. Not collected in recent years.

Lonicera japonica. Japanese honeysuckle. The most pernicious weed in the valley; in many sections completely obliterating the native vegetation by forming solid stands which cover wooded slopes and thickets.

Lonicera maackii. Maack's honeysuckle. Occasional escape. Bells Mill Road.

Lonicera sempervirens. Trumpet honeysuckle, coral-honeysuckle.Woods and thickets. Not seen in recent years and perhaps extinct.

Lonicera tatarica. Tartarian honeysuckle. Native of Eurasia. Widely planted and occasionally escaping from cultivation. Cresheim Valley, Harper's Meadow.

Sambucus canadensis. Common elder. Wet thickets and stream borders. Frequent throughout. Henry Avenue, Walnut Lane, Carpenter's Woods, Cresheim Valley, Valley Green, Thomas Mill Road, Bells Mill Road, Harper's Meadow.

Symphoricarpus orbiculatus. Coralberry. Spread from cultivation and escaped along paths and trails. Cresheim Valley, Thorps Lane.

Viburnum acerifolium. Maple-leaved arrow-wood. Dry or rocky woods. Common throughout. Walnut Lane, Bluestone Bridge, Carpenter's Lane, Cresheim Valley, Valley Green, Rex Avenue, Thomas Mill Road, Bells Mill Road, Henry Avenue.

Viburnum dentatum. Southern arrow-wood. Thickets. Hermit's Lane, Henry Avenue, Walnut Lane, Cresheim Valley.

Viburnum opulus. Guelder-rose, snowball-tree. Native of Europe. Escaped from cultivation. Carpenter's Woods, Cresheim Creek, Harper's Meadow.

Viburnum prunifolium. Black-haw. Occasional in borders of woods.

Viburnum recognitum. Arrow-wood. Wet to dry thickets. Less frequent than *V. dentatum*, which it resembles, but from which it differs in its smoother leaves and branchlets. Carpenter's Woods, Kitchen's Lane, Cresheim Creek, Valley Green.

Viburnum sieboldii. Japanese viburnum. Native of Asia. Escaped from cultivation. Walnut Lane, Cresheim Valley.

Viburnum tomentosum (*V. plicatum*). Snowball. Native of Asia. Escaped from cultivation.

Henry Avenue, Carpenter's Woods, Cresheim Creek, Cresheim Valley.

VALERIANACEA, VALERIAN FAMILY

Valerianella intermedia (*V. umbilicata*). Corn-salad, lamb's-lettuce. Damp to dry woods and meadows. Rare.

CUCURBITACEAE, GOURD FAMILY

Echinocystis lobata. Wild balsam-apple. Thickets and stream banks. Occasional. Mt. Airy Avenue, near Harper's Meadow.

Sicyos angulatus. Bur cucumber. Deep thickets and bottomland. Infrequent. Walnut Lane, Cresheim Valley.

CAMPANULACEAE, BELLFLOWER FAMILY.

Campanula aparinoides. Marsh bellflower. Low, damp ground, stream banks. Rare, and local. Allen's Lane.

Specularia perfoliata (*Triodanis perfoliata* var. *perfoliata*). Venus's-looking-glass. Occasional in open clearings, waste ground, on roadsides, etc.

LOBELIACEAE, LOBELIA FAMILY

(Campanulaceae)

Lobelia inflata. Indian-tobacco. Fields, roadsides, waste places, sometimes an abundant weed. Walnut Lane, Carpenter's Woods.

Lobelia siphilitica. Great lobelia. Rich, low woods and swamps. Occasional. Walnut Lane, Monastery, Thomas Mill Road, Thorps Lane, Harper's Meadow.

COMPOSITAE, COMPOSITE FAMILY

(Asteraceae)

Achillea millefolium. Milfoil, yarrow. Roadsides, meadows, clearings, etc. Frequent throughout. Henry Avenue, Thomas Mill Road, Harper's Meadow.

Ambrosia artemisiifolia. Common ragweed. Common throughout on roadsides, banks, disturbed ground, etc. Walnut Lane.

Ambrosia trifida. Great ragweed. Thickets, bottomland, etc. Common. The variety *integrifolia*, with leaves entire instead of three-lobed, is occasional. Walnut Lane, Cresheim Valley, Rex Avenue, Bells Mill Road, Harper's Meadow.

Antennaria fallax (*A. parlinii* ssp. *fallax*). Pussytoes. Open woods, shaded slopes, clearings, etc. Occasional. Near Harper's Meadow.

Antennaria neglecta. Pussytoes. Open, wooded slopes, clearings, etc. Fairly common. Above Bells Mill Road.

Antennaria neodioica. Pussytoes. Dry woods and open slopes. Fairly common. Thomas Mill Road.

Antennaria plantaginifolia. Pussytoes. Dry, open or shaded slopes, clearings, roadsides, etc. Common throughout. Below Barren Hill Road, Bells Mill Road.

Anthemis cotula. Mayweed. Roadsides, waste places, etc. Occasional.

Arctium minus. Common burdock. Roadsides, waste ground. Occasional. Bluestone Bridge, Walnut Lane, Carpenter's Woods, Devil's Pool, Cresheim Valley, above Thomas Mill Road, Harper's Meadow.

Artemisia vulgaris. Mugwort. Waste places. Near Walnut Lane Bridge, Carpenter's Woods.

Aster cordifolius. Common blue aster. Open woods and thickets. Fairly common. Henry Avenue, Bluestone Bridge, Walnut Lane, Livezey Lane, Cresheim Valley, Thomas Mill Road, Thorps Lane.

Aster divaricatus. White wood aster. Woods and thickets. Common. Henry Avenue, Bluestone Bridge, Walnut Lane, Kitchen's Lane, Livezey Lane, Cresheim Valley, Valley Green, Rex Avenue, Thomas Mill Road, Bells Mill Road, Harper's Meadow.

Aster ericoides (*A. pilosus*). Heath aster. Dry slopes and thickets. Occasional.

Aster lateriflorus. Aster. Moist to dry fields and thickets. Fairly frequent. Bluestone Bridge, Carpenter's Woods, Bells Mill Road.

Aster linariifolius. Aster. Dry slopes and ledges. Rare. Thomas Mill Road.

Aster novae-angliae. New England Aster. Damp thickets, meadows, etc. Infrequent. Not seen in recent years, but should be sought for.

Aster patens. Aster. Dry, open woods and thickets. Casual. Thomas Mill Road.

Aster prenanthoides. Aster. Damp thickets, borders of woods, etc. Fairly common. Henry Avenue, Bluestone Bridge, Walnut Lane, Livezey Lane, Rex Avenue, Thomas Mill Road.

Aster puniceus. Swamp aster. Damp thickets and meadows. Occasional. Cresheim Valley, Bells Mill Road.

Aster schreberi. Aster. Damp woods and thickets. Locally abundant. Walnut Lane, Rex Avenue, Bells Mill Road, below Barren Hill Road.

Aster simplex (*A. lanceolatus* ssp. *simplex*). Aster. Damp woods and thickets. Occasional. Henry Avenue, Bluestone Bridge, Walnut Lane, Carpenter's Woods, Livezey Lane, Cresheim Valley, Thomas Mill Road, Harper's Meadow.

Aster undulatus. Aster. Occasional in dry woods and thickets.

Aster vimineus (*A. lateriflorus*). Aster. Damp to dry woods and clearings. Rare.

Bidens bipinnata. Spanish needles. Roadsides and waste places. Occasional.

Bidens cernua. Stick-tight. Muddy shores, springs, etc. Occasional.

Bidens comosa. Beggar-ticks. Occasional in low, wet ground. Thorps Lane.

Bidens frondosa. Stick-tight. A weed along roadsides, or in waste ground. Harper's Meadow.

Bidens vulgata. Stick-tight. Widely distributed in low ground, ditches, waste places, etc.

Chrysanthemum leucanthemum. Ox-eye daisy. Dry roadsides, clearings, fields, etc. Ours is the variety *pinnatifidum* with dissected leaves. Frequent.

Chrysopsis mariana. Golden aster. Dry, sandy soil. Rare. Carpenter's Woods.

Cichorium intybus. Chicory. Casual throughout. Bells Mill Road.

Cirsium arvense. Canada thistle. Clearings and waste ground. Occasional. Walnut Lane.

Cirsium discolor. Thistle. Thickets, stream banks, etc. Infrequent. Cresheim Valley.

Cirsium lanceolatum (*C. vulgare*). Bull-thistle. Roadsides and clearings. Occasional. Bells Mill Road.

Eclipta alba (*E. prostata*). White eclipta. Muddy shores. Livezey Lane.

Erechtites hieracifolia. Fireweed. Damp thickets and clearings. Occasional. Walnut Lane, Cresheim Valley, Bells Mill Road, near Harper's Meadow.

Erigeron annuus. Daisy fleabane. Clearings and waste places. Scattered throughout.

Erigeron canadensis (*Conyza canadensis* var. *canadensis*). Horseweed. An occasional weed of cleared areas and roadsides. Walnut Lane.

Erigeron pulchellus. Robin's-plantain. Open woods, thickets, and dry clearings. Sporadic. Cresheim Creek, Rex Avenue.

Erigeron strigosus. White-top. Open slopes, roadsides, etc. Infrequent.

Eupatorium fistulosum. Joe-pye-weed. Damp thickets, borders of woods, meadows. Common throughout. Bluestone Bridge, Walnut Lane, Cresheim Valley, Thomas Mill Road, Bells Mill Road, Harper's Meadow.

Eupatorium perfoliatum. Boneset, thoroughwort. Damp thickets and meadows. Fairly abundant. Walnut Lane, Thomas Mill Road, Bells Mill Road, Harper's Meadow.

Eupatorium purpureum. Sweet joe-pye-weed. Damp woods and thickets, moist shaded roadsides. Common. Henry Avenue, Bluestone Bridge, Walnut Lane, Kitchen's Lane, Mt. Airy Avenue, Valley Green, Rex Avenue, Thomas Mill Road, Bells Mill Road, Harper's Meadow.

Eupatorium rugosum. White-snakeroot. Rich woods, thickets, and clearings. Abundant throughout. Henry Avenue, Bluestone Bridge, Walnut Lane, Kitchen's Lane, Carpenter's Woods, Cresheim Valley, Rex Avenue, Thomas Mill Road, Harper's Meadow.

Galinsoga ciliata (*G. quadriradiata*). Galinsoga. A ubiquitous weed of clearings, roadsides, etc. Walnut Lane, Livezey Lane, Cresheim Valley, Rex Avenue, Thomas Mill Road, Harper's Meadow.

Gnaphalium obtusifolium. Cudweed, everlasting. Dry slopes and clearings. Occasional.

Helenium autumnale. Sneezeweed. Rich thickets and fields. Rare. Below Walnut Lane.

Helenium nudiflorum (*H. flexuosum*). Sneezeweed. Roadsides and clearings. Rare.

Helianthus decapetalus. Thin-leaf sunflower. Woods and thickets. Frequent. Mouth of creek, Henry Avenue, Bluestone Bridge, Walnut Lane, Kitchen's Lane, Mt. Airy Avenue, Valley Green, Thomas Mill Road, Bells Mill Road, Harper's Meadow.

Helianthus divaricatus. Sunflower. Dry, sterile or sandy soil. Rare.

Helianthus tuberosus. Jerusalem artichoke. Thickets, borders of woods, etc. Occasional.

Heliopsis helianthoides. Ox-eye. Open woods and thickets. Rare.

Hieracium paniculatum. Hawkweed. Open woods and shaded slopes. Frequent. Henry Avenue, Bluestone Bridge, Walnut Lane, Kitchen's Lane, Mt. Airy Avenue, Cresheim Valley, Valley Green, Thomas Mill Road, Bells Mill Road.

Hieracium scabrum. Hawkweed. Dry woods and thickets. Occasional. Bells Mill Road.

Hieraceum venosum. Rattlesnake-weed. Open woods and clearings. Occasional. Carpenter's Woods, Thomas Mill Road, Bells Mill Road.

Inula helenium. Elecampane. Cleared ground. Rare. Found years ago near Thorps Lane. Perhaps no longer growing in the valley.

Krigia biflora. Dwarf dandelion. Dry, usually sandy soil. Rare. Carpenter's Woods.

Lactuca biennis. Tall lettuce. Thickets, borders of woods, and clearings. Common throughout. Bluestone Bridge, Walnut Lane, Kitchen's Lane, Mt. Airy Avenue, Cresheim Valley, Valley Green, Thomas Mill Road, Bells Mill Road, Harper's Meadow.

Lactuca canadensis. Wild lettuce. Thickets, borders of woods, and clearings. Infrequent.

Lactuca floridana var. *villosa*. Blue-flowered lettuce. Dry thickets and roadsides. Rare. Rex Avenue.

Lactuca scariola (*L. serriola*). Prickly lettuce. Roadsides and clearings. Occasional.

Prenanthes altissima. Rattlesnake-root. Damp to dry woods and thickets. Common throughout. Walnut Lane, Carpenter's Woods, Mt. Airy Avenue, Valley Green, Rex Avenue, Thomas Mill Road, Bells Mill Road, Harper's Meadow.

Prenanthes trifoliolata. Gall-of-the-earth. Rich to dry woods. Fairly frequent. Cresheim Valley, Valley Green, Thomas Mill Road.

Rudbeckia hirta. Black-eyed-Susan. Dry, open places. Occasional.

Rudbeckia laciniata. Tall coneflower. Rich, moist thickets and bottomlands. Common. Henry Avenue, Bluestone Bridge, Walnut Lane, Kitchen's Lane, Devil's Pool, Cresheim Valley, Thomas Mill Road, Bells Mill Road, Harper's Meadow.

Rudbeckia triloba. Coneflower. Naturalized occasionally in open woods, thickets, and clearings.

Senecio aureus. Golden ragwort. Occasional in low, swampy ground. Cresheim Creek, Bells Mill Road, Harper's Meadow.

Sericocarpus asteroides (*Aster paternus*). White-topped aster. Dry, open woods and clearings. Rare. Carpenter's Woods, along bridle path, south of Bells Mill Road, near summit of trail.

Silphium perfoliatum. Cup-plant. Rich woods and thickets. Infrequent. Below Henry Avenue, near Harper's Meadow.

Solidago altissima (*S. canadensis*). Tall goldenrod. Dry to damp thickets and clearings. Fairly frequent. Hermit's Lane, Walnut Lane, Cresheim Valley, Thomas Mill Road, Harper's Meadow.

Solidago arguta. Goldenrod. Open woods, thickets, and clearings. Infrequent. Not seen in recent years.

Solidago bicolor. Silver-rod. Frequent in dry woods, thickets, and fields. Frequent. Walnut Lane, Carpenter's Woods, Cresheim Valley, Thomas Mill Road, Bells Mill Road.

Solidago caesia. Blue-stemmed goldenrod. Damp, rich woods and thickets. Common. Henry Avenue, Bluestone Bridge, Walnut Lane, Carpenter's Woods, Mt. Airy Avenue, Cresheim Valley, Rex Avenue, Thomas Mill Road, Bells Mill Road, Harper's Meadow.

Solidago canadensis. Canada goldenrod. Rich woods and thickets. Rare.

Solidago gigantea. Goldenrod. Rich thickets, swamps, etc. Freqent. Walnut Lane, Cresheim Valley, Thomas Mill Road, Bells Mill Road, Harper's Meadow.

Solidago graminifolia (*Euthamia graminifolia* var. *graminifolia*). Flat-top goldenrod. Thickets and meadows. Carpenter's Woods, Cresheim Valley, Thomas Mill Road.

Solidago juncea. Goldenrod. Dry, open places. Rare. Bells Mill Road.

Solidago latifolia (*S. flexicaulis*). Goldenrod. Rich woods and thickets. Common. Henry Avenue, Bluestone Bridge, Walnut Lane, Carpenter's Woods, Mt. Airy Avenue, Livezey Lane, Thomas Mill Road, Bells Mill Road, Harper's Meadow.

Solidago nemoralis. Goldenrod. Dry, sterile clearings and fields. Rare. Carpenter's Woods, Bells Mill Road, below Barren Hill Road.

Solidago odora. Anise-scented goldenrod. Dry, open woods and meadows. Rare. Thorps Lane.

Solidago puberula. Goldenrod. Dry, sterile slopes and clearings. Rare.

Solidago rugosa. Goldenrod. Wet thickets and stream banks. Frequent. Henry Avenue, Bluestone Bridge, Walnut Lane, Carpenter's Woods, Thomas Mill Road, Cresheim Valley, Bells Mill Road.

Solidago squarrosa. Goldenrod. Dry, rocky woods and shaded slopes. Rare. Collected in 1866 but no locality given.

Solidago ulmifolia. Goldenrod. Dry, rocky woods and thickets. Rare. Thorps Lane.

Sonchus asper. Sow-thistle. Roadsides, waste ground, etc. Sporadic. Henry Avenue.

Taraxacum officinale. Common dandelion. An ever-present weed of roadsides, clearings, disturbed ground, etc. Bluestone Bridge, Livezey Lane, Thomas Mill Road, Harper's Meadow.

Vernonia novaboracensis. Iron-weed. Wet thickets and low, swampy ground. Occasional. Cresheim Valley.

Xanthium italicum (*X. strumarium* var. *canadense*). Cocklebur. Low ground, stream banks and waste places, etc. Thorps Lane.

Xanthium pensylvanicum (*X. strumarium* var. *canadense*). Cocklebur. Bottomland, waste places, etc. Occasional. Cresheim Valley, Harper's Meadow.

Bartonia No. 59: 37-47, 1996

The Identity of *Anemone riparia* (Ranunculaceae)

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In recently reviewing the *Anemone virginiana* L. complex in Pennsylvania, it has become apparent that the name, *Anemone riparia* Fernald (as described by Fernald in 1899), has been applied to a discordant set of elements. In general, systematists have determined specimens as *A. riparia* based on either (1) larger sepal size (up to 2 cm long), or (2) presence of cuneate-based leaf divisions. These disparate treatments have led to a considerable divergence regarding the identity of *A. riparia*, as well as different opinions with respect to its range throughout Canada and the eastern United States. Consequently, the principal aim of this study is to clarify the identity of Fernald's *A. riparia* and to apply these results to a more discriminating analysis of the *A. virginiana* complex within North America.

HISTORICAL OVERVIEW

In 1899, M. L. Fernald described a new species of *Anemone* characterized by relatively large sepals (1.5-2.0 cm long), subcylindric fruiting heads, suberect styles, and cuneate-based, thin leaflets and which occurs chiefly on calcareous river banks, rocky shores, and moist cliffs in eastern Canada and northeastern United States (Fernald 1899; Robinson & Fernald 1908). Because of continued confusion between *A. riparia* and *A. virginiana*, Fernald (1917) later attempted to sharpen the differences by comparing leaf segment bases, anther lengths, thickness of fruiting heads and style orientation. Fernald's remarks are pertinent: "Contrasted with *A. virginiana* it [*A. riparia*] has the leaf-segments usually more cuneate at base, although this character is by no means absolute; anthers 0.7-1.2 mm. long, those of the more southern *A. virginiana* running from 1.2-1.6 mm. long; its fruiting head 7-11 mm. thick, as contrasted with *A. virginiana* in which the heads are 1.2-1.5 cm. thick; and the subulate pale styles ascending or subascending in fruit, as contrasted with the firmer, more divergent styles of *A. virginiana*" (Fernald 1917). Moreover, Fernald (1917) noted that both taxa have polymorphic sepals ranging from small, more or less inconspicuous to large, white petaloid forms, leading him to name several of these variants. Fernald also named one color form (f. *rhodantha*) of *A. riparia*. These observations were repeated in Fernald's key to *Anemone* in the eighth edition of *Gray's Manual of Botany* (Fernald 1950, p. 661).

Meanwhile, other taxonomists formed their own opinions concerning the identity of *A. riparia*. In both his large-scaled treatments of the flora of the southeastern United States, Small (1903, 1933) distinguished *A. riparia* from *A. virginiana* on the basis of sepal color, size of fruiting head, and style orientation, *A. riparia* having clear white sepals, fruiting heads less than 1 cm thick, and achenes with appressed or ascending styles. *Anemone virginiana*, on the other hand, is distinguished by its greenish sepals, fruiting heads greater than 1 cm thick, and achenes with spreading styles. Moreover, Small claimed that *A. riparia* occurred on "[b]anks, often calcareous stony soil, Blue Ridge and more northern provinces, N.C. to Tenn., Alb., and Que." (Small 1933, p. 517).

In the second edition of their *Illustrated Flora*, Britton and Brown (1913) listed *A. riparia* as a synonym of *A. virginiana*. But in the revision of Britton and Brown's *Illustrated Flora*, Gleason (1952) followed Fernald in recognizing both *A. riparia* and *A. virginiana*. Gleason's key (1952, Vol. 2, p. 180) distinguished both species on the basis of leaf segment patterns and style orientation. However, Gleason remarked that "the taxonomic status of the group of plants described under this name [*A. riparia*] is still open to question" (1952, p. 180). By the time the one-volume *Manual* was produced (Gleason & Cronquist 1963), Gleason and Cronquist reverted to Britton and Brown's earlier view by lumping *A. riparia* with *A. virginiana*. Gleason and Cronquist observed, however, that "[s]ome plants from the northern part of the range diverge toward *A. cylindrica* [distinguished from the *A. virginiana* complex by its 5-9-leaved involucre, naked peduncles, and generally narrower, more cylindric fruiting heads] in their somewhat narrower heads and in having the l[ea]f-segments more cuneate below. These have been segregated as *A. riparia* Fern., but they do not appear to be sharply separable from *A. virginiana*" (Gleason & Cronquist 1963, p. 316). In the second edition of the *Manual*, Gleason and Cronquist (1991, p. 52) continued to include *A. riparia* with *A. virginiana*, and with only the addition "...var. *alba* A. Wood or...," the same comment quoted above is repeated in the newer edition.

Over the years these disparate views concerning the taxonomic disposition of *A. riparia* have been reflected in the floristic treatments of other authors. For example, Rydberg (1932, pp. 332-333) generally followed Fernald, but considerably expanded the range of *A. riparia* ("River banks: Me.-Va.-Alta.") and distinguished *A. riparia* from *A. virginiana* chiefly on the basis of style orientation, and sepal color and length ("Petals [sic] white, 1.5 cm. long" vs. "Petals greenish white, 1 cm. long or less," respectively). Deam (1940) viewed *A. virginiana* as a variable species, especially with respect to the stamen length, and sepal size, shape, color, and texture, and concluded that "after a careful study of 77 specimens from all parts of [Indiana] I have decided that the characters are too variable to be of taxonomic value." Both Scoggan (1957) and Seymour (1969) recognized *A. riparia*, but except for leaf pubescence (Seymour), they added no new characters separating these two species.

In a study of the flora of the prairie provinces of Canada, Boivin (1968, 1969) concluded that, based on the smaller flowers (sepals ±1 cm long, greenish) and narrower, more cylindric fruiting heads, the elements of the *A. virginiana* complex in that region should belong to a taxon he named var. *cylindroidea*. Boivin observed that his new variety "[r]anges in Canada from southern Quebec west to northern British Columbia," but "[g]rades eastward into var. *riparia* and var. *virginiana*" (Boivin 1969). Boivin (1969) noted also that "[s]upposed differences in leaf shape have not proved worth retaining," and that the "name var. *riparia* (Fern.) Boivin 1966 for the large flowered eastern plant should be replaced by the earlier and correct var. *alba* Wood 1861" (see Boivin 1966, 1967, and Wood 1861, p. 203).

During the past decade, Mitchell and Dean (1982) reviewed the *Anemone virginiana* complex for New York and concluded that "[t]his seldom-studied group of plants presents some interesting problems in variation." They suggested, moreover, that "var. *alba* Wood [= *A. riparia*] was derived through ancient hybridization of *A. virginiana* and *A. cylindrica* [generally sympatric with *A. virginiana* northward], and has now backcrossed to *A. virginiana* sufficiently to form a morphological bridge as well as an ecological cline. Variety *alba* has a much broader northern range than typical var. *virginiana*, and has apparently inherited the heterozygosity needed for postglacial invasion of cool, moist habitats—thus expanding the range of the species." Voss (1985, pp. 229-230) treated *A. virginiana* "in a broad sense" and pointed out that large-flowered plants "were named as *A. virginiana* var. *alba* Wood and were included in *A. riparia* Fern., a name often applied (but frequently with some misgivings) to certain plants in our area." Voss noted that "[d]istinctions in anther length, sometimes cited, appear useless, and the angle of the style is scarcely better. Typical var. *virginiana* tends to have fatter, more ovoid fruiting heads (to 17 mm thick) and to be larger-leaved, the leaf segments more ovate, than var. *alba*, which in some ways approaches *A. cylindrica*." Finally, in the *Flora of the Great Plains*, Sutherland (1986) merely listed *A. riparia* as a synonym under *A. virginiana* without comment.

In summary, two points should be stressed: (1) taxonomists are not in agreement concerning the recognition of the taxonomic group variously named *A. riparia* Fernald or *A. virginiana* L. var. *alba* A. Wood, and (2) taxonomists have separated *A. riparia* from *A. virginiana* on the basis of a differential set of characters. These are chiefly sepal size and color *or* shape of leaflet bases, although anther length, style orientation, thickness and shape of fruiting heads, and leaf pubescence have been used also as discriminators. Undeniably, by recognizing different sets of characters, taxonomists have developed disparate taxonomic treatments of this complex. The aim of this study, therefore, is to clarify the identity and taxonomic status of *Anemone riparia* by means of an analysis of the character states previously identified as possible discriminators between this taxon and *A. virginiana*. A secondary aim is to evaluate the status of Boivin's var. *cylindroidea*, and thus round out a preliminary taxonomic treatment of the *Anemone virginiana* complex.

MATERIALS AND METHODS

A total of 341 specimens from throughout the range of the *A. virginiana* complex (specimens were borrowed from A, CM, DAO, F, GH, NEBC, NYS, PAC, PH) were scored for the shape of the involucral leaf base (truncate-obtuse or cordate-reniform; involucral leaves were selected because not all specimens had basal leaves which are larger but similar in overall shape), and the shape of the basal portion of the central leaflet divisions (concave, straight, convex). Subsamples with well-preserved floral organs were selected from herbarium material of each taxon. The lengths of sepals and anthers and the length and thickness of the fruiting heads were measured to the nearest 0.1 mm. Style orientation and leaf pubescence are too indeterminate and so were omitted from any further analysis. Flower and fruiting head measurements were compared by using the Ryan-Einot-Gabriel-Welsch multiple range test option of the SAS analysis-of-variance procedure. This test minimizes rejection of the null hypothesis (that two samples are equal) when it is indeed true. The taxon with the minimum number of preserved flowers (N = 32) or fruiting heads (N = 30) determined the sample size for the REGW/ANOVA. The analysis was done on the IBM 3090/180 computer at the University Park Campus of The Pennsylvania State University.

Ideally, all characters should be measured from a set of complete specimens. Given that useful characters included both flowering and fruiting material, this proved impossible in practice. This also precluded any attempted correlation analysis involving, e.g., sepal length and fruiting head length and thickness all obtained from the same specimen. Consequently, for purposes of this study, we initially classified all specimens into three groups based on a critical comparison with the type specimens of *Anemone riparia* and *A. virginiana* var. *cylindroidea*. Measurements were taken from subsamples of each group. It would have been preferable to have pooled all the data and then derive a principal components analysis, but the specimens we utilized simply lacked one or more of the critical characters. Our study, thus, reflects an analysis based on a pooled grouping of initially classified herbarium specimens and therefore lacks some of the rigor that a thorough population-based study would have yielded.

RESULTS

The results of the multiple range test indicate that the differences in sepal length among all three taxa are significantly different (Table 1). *Anemone virginiana* var. *cylindroidea* shows relatively little variation around the shortest mean length. The sepal measurements of var. *alba* overlap the range of var. *virginiana* but average 2 mm longer. The differences in anther length and fruiting head thickness between var. *alba* and var. *cylindroidea* are not significant but these taxa have significantly shorter anthers and narrower fruiting heads than var. *virginiana*. The three taxa are not significantly different in fruiting head length.

TABLE 1. Statistical comparison of selected characters of the varieties in the *Anemone virginiana* complex with mean ± s.d., range, and *N*.[1]

Character	*cylindroidea*	*alba*	*virginiana*
Sepal length (mm)	7.2±1.2^a, 5-10, 33	15.2±3.3^b, 9-21, 33	12.9±3.5^c, 6-21, 39
Anther length (mm)	0.9±0.1^a, 0.7-1.2, 32	1.0±0.2^a, 0.8-1.5, 32	1.3±0.2^b, 0.9-1.7, 32
Fruiting head length (mm)	19.8±4.5^a, 13-36, 30	19.0±2.4^a, 13-24, 34	19.2±3.2^a, 12-28, 30
Fruiting head thickness (mm)	8.7±1.2^a, 7-11, 30	9.1±1.0^a, 8-11, 33	11.0±1.2^b, 9-14, 33

[1] Results based on a Ryan-Einot-Gabriel-Welsch multiple range test (alpha = 0.01). Mean values followed by the same letter are judged not significantly different.

With respect to the involucral leaves, the base of the central leaflet or division in var. *virginiana* is straight-sided in about half the specimens, the other half being divided about equally between those with concave sides and those with convex sides (Table 2). In var. *cylindroidea* the basal leaflet edges are again predominantly straight, with about 25% of the specimens having concave sides and fewer than 5% are convex. However, in var. *alba* the predominant shape is concave and although about one-third of the specimens are straight-sided, no convex edges were observed. *Anemone virginiana* var. *alba* also shows a higher percentage of leaves with truncate-obtuse bases whereas var. *virginiana* (and var. *cylindroidea*—despite missing data) generally has cordate leaf bases (Table 2).

TABLE 2. Involucral leaflet morphology.

Taxon		Lower margin of central leaflet (percent) concave	straight	convex		Base of involucral leaves (percent) truncate	cordate
var. *cylindroidea*	(N=57)	25	70	5		—	—
var. *alba*	(N=64)	65	35	0	(N=71)	82	18
var. *virginiana*	(N=58)	21	53	26	(N=58)	20	80

Clearly, no single character demarks unequivocally any variety from the other two. Furthermore, the continuous nature of the variables makes the determination of some specimens, especially from the northern interior of the geographic range rather problematic. Nevertheless, at the limits of the overall range, the three taxa are sufficiently distinct with respect to the ensemble of five characters (viz., sepal and anther length, fruiting head thickness, margins of central involucral leaflets, base of involucral leaves; all five characters should be employed to avoid the confusion resulting from utilizing differential sets of characters) that in our opinion they should be recognized as varieties of a wide-ranging polymorphic species. Critical population studies might well change this conclusion, and, in fact, it would be desirable to conduct such studies in the northern part of the range of *Anemone virginiana*, especially in the area from the Great Lakes eastward to Newfoundland. In our study, no evidence of hybridization appeared to exist. Hybridization experiments involving all three taxa would be desirable.

TAXONOMY

Anemone virginiana L.

Tall, caudiciferous or short-rhizomatous, perennial herb; stems 0.5-1.0 m tall, loosely pubescent. Basal leaves compound or deeply 3-parted, broadly reniform to cordate-ovate in outline, to 15 cm wide; central segments or leaflets rhombic-ovate in outline, variously parted, cleft, lobed or incised, margins crenate to serrate distally, basally concave, cuneate, or convex, thinly pubescent; petioles to 2.8 dm long, variously pubescent. Involucral leaves similar to basal leaves, usually smaller, lower whorled, upper opposite; base of leaf outline ±cordate or reniform to nearly truncate; petioles 1-8 cm long; central segments or leaflets to 12 cm long and 6 cm wide, firm, green to dark green above, lighter or pale green below, variously pubescent on both surfaces, apices acute, margins variously lobed, incised, serrate or crenate, bases convex, cuneate, or rounded, base to lower lobe notch 2.6-6.4 cm, petiolules to 1 cm long. Inflorescence terminal, (1-)3-5(-9) flowered, usually with an opposite-leaved secondary involucre. Sepals typically 5, separate, whitish or greenish-white, ovate to obovate, 5-21 mm long, leathery to thin, variously pubescent abaxially; petals or staminodia absent; stamens numerous, anthers cylindrical, 0.7-1.7 mm long, filaments capillary, to 7 mm long, glabrous. Fruiting heads ovoid, oblong-cylindric to cylindric, to 3.6 cm long, 0.7-1.4 cm thick; achenes brownish, compressed, obovoid, ca. 1.5 mm. broad, densely woolly; styles greenish to purplish apically, spreading to ascending, 1-2 mm long, short-pubescent or sometimes glabrous apically. Chromosome no.: $n = 8$. Three intergradient varieties.

Key to Varieties of *Anemone virginiana*

1. Sepals greater than 1 cm long, usually thinly pubescent abaxially; anthers usually greater than 1 mm long; wide-ranging plants of moist habitats 2

1. Sepals less than 1 cm long, densely tomentose abaxially; anthers usually less than 1 mm long; mostly Canadian plants of dry woods, sandy ridges and grasslands . . . . var. *cylindroidea*

  2. Base of involucral leaves ±cordate or reniform (rarely subtruncate), the margins of the central leaflets basally mostly straight to convex-sided, generally light green, variously lobed or serrate, variously pubescent; anthers typically greater than 1.1 mm long; fruit-

ing heads ovoid to ovoid-cylindric, often greater than 11 mm thick; plants of dry rocky open woods, slopes, moist thickets, etc.; wide-ranging . . . . var. *virginiana*

2. Base of involucral leaves often truncate to subtruncate (sometimes reniform or cordate), the margins of the central leaflets basally concave to straight-sided, generally deep green, apically incised, thinly pubescent; anthers typically less than 1.2 mm long; fruiting heads ±ovoid-cylindric, ca. 10 mm thick; plants of riparian areas, moist cliffs and ledges, etc.; chiefly New England and adjacent Canada . . . . var. *alba*

1. **Anemone virginiana L. var. virginiana** (Fig. 1)

Anemone virginiana L., Sp. Pl. 1: 540. 1753. TYPE: Habitat in Virginia (Lectotype: LINN-IDC Microfiche 710.19, designated by Reveal et al. 1992).

Anemone virginiana f. *leucosepala* Fernald, Rhodora 19: 140. 1917. TYPE (so designated on the herbarium sheet in GH): North Carolina, Biltmore, June 28 and August 9, 1897, *Biltmore Herbarium no. 54b* [GH!; specimen of 28 June (in flower and mounted on left side of sheet) herein designated as LECTOTYPE inasmuch as there are specimens of two different dates on the same sheet (9 Aug specimen in fruit)].

Anemone virginiana f. *rubrosepala* House, New York State Mus. Bull. 243-244: 26. 1923. TYPE: New York, Greene Co., Cairo, June 18, 1918, *L. S. Slater s.n.* (Holotype: NYS!).

Anemone virginiana f. *plena* E. J. Palmer & Steyermark, Brittonia 10: 113. 1958. TYPE: Missouri, St. Louis Co., Rockwoods Reservation, 1956, *G. E. Moore s.n.* (Holotype: F!).

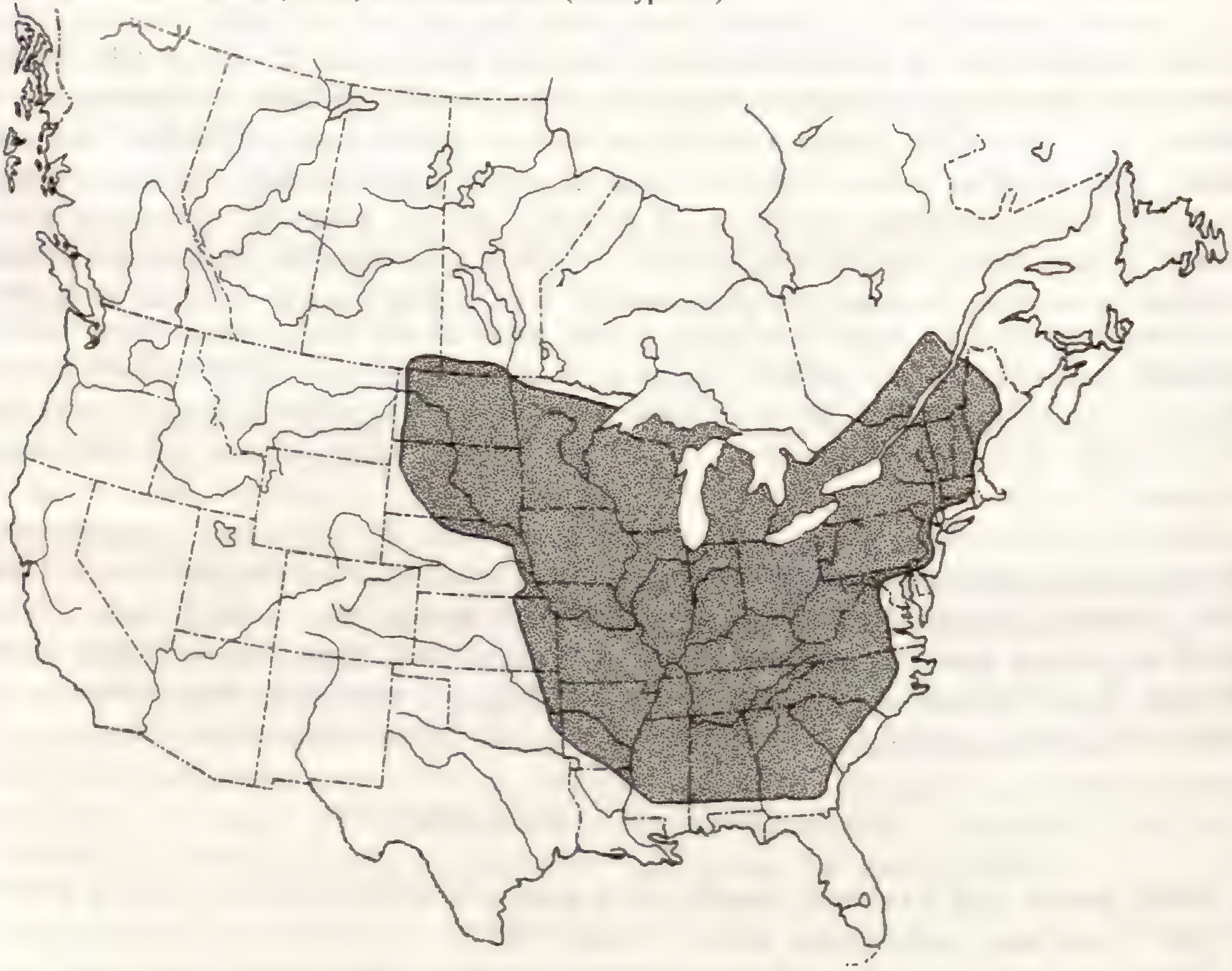

Fig. 1. Distribution of *Anemone virginiana* var. *virginiana* in North America.

Base of involucral leaves ±cordate or reniform to rarely subtruncate; central leaflets lobed and variously toothed, basal margins mostly convex to cuneate, typically light green and variously pubescent. Sepals 6-21 (ave.: 12.9; N = 39) mm long, thinly pubescent abaxially; anthers 0.9-1.7 (ave.: 1.3; N = 32) mm long; fruiting heads 12-28 (ave.: 19.2; N = 30) mm long, 9-14 (ave.: 11.0; N = 33) mm thick, ovoid to ovoid-cylindric. Flowering in June to August; fruiting in July to September. Herbs of dry rocky open woods, slopes, thickets, and river banks throughout eastern North America from southeastern Georgia to northeastern Louisiana, eastern Oklahoma, eastern Kansas and eastern and northern Nebraska, north to western North Dakota, east to central Maine and south-central Quebec (Roberval) (Fig. 1).

Anemone virginiana f. *leucosepala* Fernald is a large-sepalled (18 mm long) form with the typical anthers (1.2 mm long) of *A. virginiana* var. *virginiana*. Except for the concave leaflet bases (comparable to *A. virginiana* var. *alba*) the specimens (flowering, one fruiting peduncle) are otherwise similar to var. *virginiana*.

Anemone virginiana f. *rubrosepala* House is a reddish-sepalled variant of var. *virginiana*. Its general habit, long anthers (1.5 mm long), and convex involucral leaflet bases certainly place it with var. *virginiana*.

Anemone virginiana f. *plena* E. J. Palmer & Steyermark is based on a large plant bearing flowers with many sepal-like sterile stamens.

2. **Anemone virginiana var. alba** (Oakes) A. Wood (Fig. 2)

Anemone cylindrica var. *alba* Oakes, Mag. Hort. Bot. vii: 182. 1841. TYPE: Vermont, Rutland Co., Castleton, *Dr. Robbins s.n.* (Lectotype, herein designated: GH!; specimen with shorter sepals and anthers, mounted on the right side of sheet). *Anemone virginiana* ß *alba* (Oakes) A. Wood, Class-book Bot. (ed. 1847): 140. 1847; *Anemone virginiana* ß *alba* [Oakes] A. Wood, Class-book Bot. (ed. 1861): 203. 1861.

Anemone riparia Fernald, Rhodora 1: 51. 1899. TYPE: Maine, Piscataquis Co., Dover, June 25, 1894, *M. L. Fernald s.n.* (Lectotype, herein designated: GH!). *Anemone virginiana* var. *riparia* (Fernald) B. Boivin, Naturaliste Canad. 94: 645. 1967.

Anemone riparia f. *rhodantha* Fernald, Rhodora 19: 139. 1917. TYPE: Canada, Quebec, Gaspé County, banks of the Grand River, July, 1902, *G. H. Richards s.n.* (Holotype: GH!). *Anemone virginiana* var. *riparia* forma *rhodantha* (Fernald) B. Boivin, Naturaliste Canad. 94: 645. 1967.

Anemone riparia f. *inconspicua* Fernald, Rhodora 19: 140. 1917. TYPE: Canada, Quebec, Gaspé County, Percé Mt., Percé, July 25, 1905, *Williams, Collins & Fernald s.n.* (Holotype: GH!).

Base of involucral leaves truncate to subtruncate, occasionally reniform or cordate; central leaflets sharply toothed to incised, basal margins usually cuneate to concave, typically dark green and sparsely pubescent. Sepals 9-21 (ave.: 15.2; N = 33) mm long; anthers 0.8-1.7 (ave.: 1.0; N = 32) mm long; fruiting heads 13-24 (ave.: 19.0; N = 34) mm long, 8-11 (ave.: 9.1; N = 33) mm thick, ±ovoid-cylindric. Flowering in mid-May to mid-July; fruiting in late June to September. Herbs of ledges, bluffs, rocky outcrops, open woods, alluvial river thickets, lake shores, and roadsides, often in calcareous soil, ranging throughout the New England states and adjacent Canada from western Newfoundland and Anticosti Island to Victoria Co., Nova Scotia, south through eastern Quebec and New Brunswick to Connecticut and southeastern New York, north through southern Ontario to Moose Factory (Cochrane Terr. Dist.), southwestward to northern Michigan, Minnesota, and eastern Wisconsin (Fig. 2).

In 1841 when William Oakes named a new variety of *Anemone cylindrica* his protologue was: "Anemone cylindrica Gray. Torrey and Gray, Flora, I., 13. var. álba Oakes. Flowers larger, sepals white. On rocky ledges in Castleton, Burlington, and other places in Vermont, also in Uxbridge, Mass. Dr. Robbins, 1829" (Oakes 1841). Shortly thereafter, this variety was taken up by Alphonso Wood in the second (1847) edition of his *Class-Book of Botany* under the name of *A. virginiana* ("ß *alba*. Oakes. *Fls.* larger; *sep.* white.—Ledges, Vt. *Dr. Robbins*."). However, when M. L. Fernald described *A. riparia* (Rhodora 1: 51. 1899) he listed two synonyms: "*A. cylindrica*, var. *alba*, Oakes, Hovey's Mag. vii. 182.

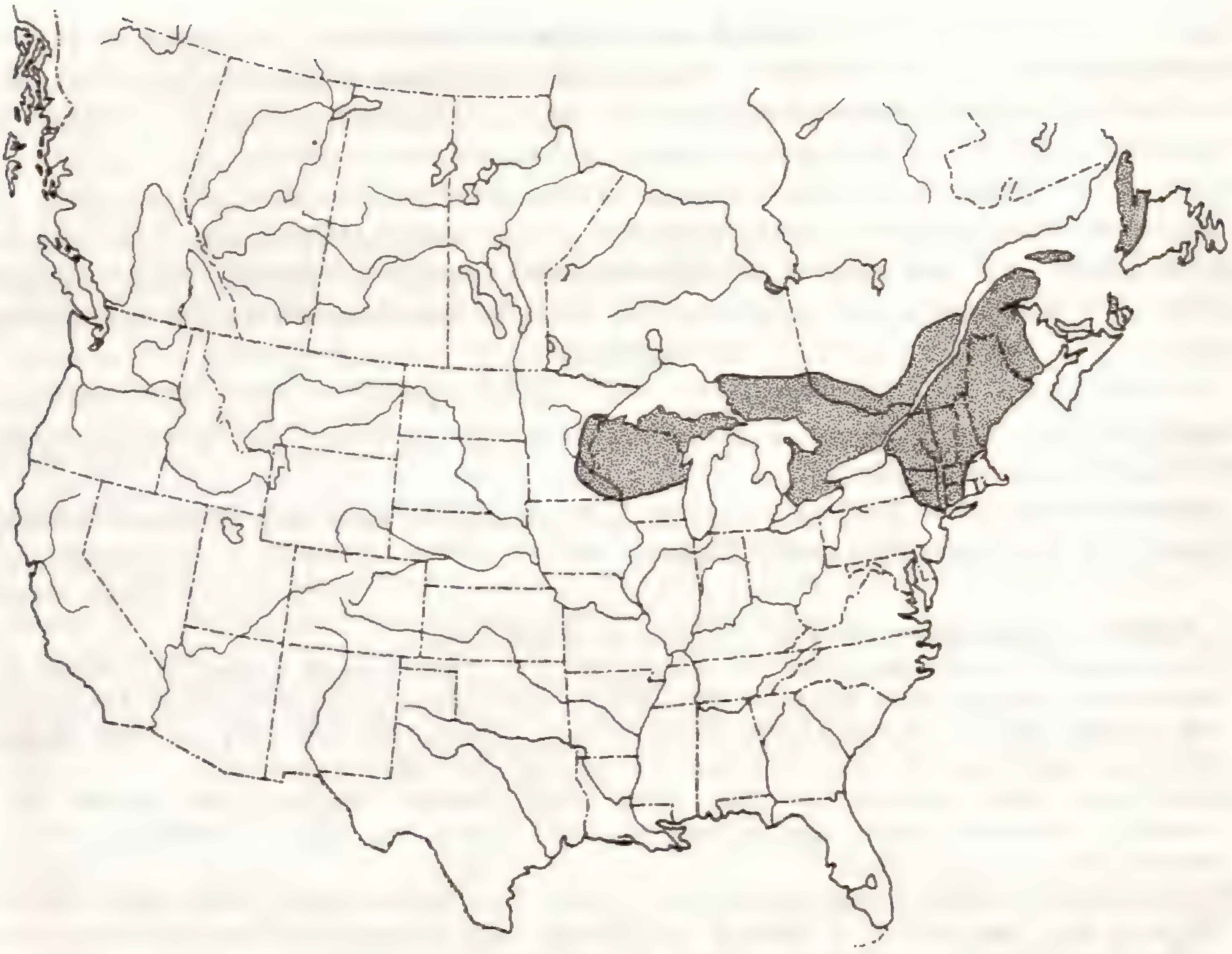

Fig. 2. Distribution of *Anemone virginiana* var. *alba* in North America.

A. virginiana, var. *alba*, Wood, Class Book, 203." Nevertheless, it appears that Fernald consulted A. Wood's edition of 1861 in which var. *alba* was given as "ß. *alba*. Fls. larger; sep. white.—Ledges, Vt. (Dr. Robbins.)." Consequently, we conclude that in the 1861 edition Wood simply deleted Oakes as author of the basionym, but Fernald, apparently unaware of Wood's earlier (1847) transfer of Oakes's var. *alba* to *A. virginiana*, assumed that Wood was the only author of *A. virginiana* var. *alba* and so listed the name ("*A. virginiana*, var. *alba*, Wood, Class Book, 203") in his description of *A. riparia* in 1899. This mistake has been perpetuated recently by Boivin (1969, p. 282): "The name var. *riparia* (Fern.) Boivin 1966 for the larger flowered eastern plant should be replaced by the earlier and correct var. *alba* Wood 1861." Mitchell and Dean (1982), and Voss (1985) followed suit in referring to "var. *alba* Wood," but they did not recognize this taxon (i.e., Fernald's *A. riparia*) as occurring in New York and Michigan, respectively.

Lectotypification of *Anemone cylindrica* A. Gray var. *alba* Oakes is based on a sheet in GH bearing a label "*Anemone virginiana alba - grandiflora*. Castleton, Vt. Dr. Robbins. Oakes" and appears closest to Oakes's protologue as given above. The sheet consists of two specimens, apparently representing two different plants. Both specimens have cuneate-based central involucral leaflets. However, one specimen has light-green leaves, sepals ca. 17 mm long, anthers ca. 1.4 mm long, and has the general aspect of *A. virginiana* var. *virginiana*. The second specimen has dark-green leaves, sepals ca. 14 mm long, anthers ca. 1.0 mm long, and is referable to Fernald's *Anemone riparia*. Accordingly, we are designating this specimen (with the smaller sepals and shorter anthers, and mounted on the right side of the sheet) as the lectotype for *A. cylindrica* var. *alba* Oakes (= *A. virginiana* var. *alba* (Oakes)

A. Wood).

Anemone riparia f. *rhodantha* Fernald, based on a very poor specimen (one flower with purplish sepals 15 mm long and anthers ca. 1 mm long, no basal leaves, but with badly pressed involucral leaves), probably belongs to var. *alba*.

Anemone riparia f. *inconspicua* Fernald is based on a specimen with two flowers having sepals 9-11 mm long and anthers ca. 1 mm long. Except for the relatively shorter sepals (though not as short as those in var. *cylindroidea*), the type is clearly var. *alba*.

3. **Anemone virginiana var. cylindroidea** B. Boivin (Fig. 3)

Anemone virginiana var. *cylindroidea* B. Boivin, Phytologia 18: 281. 1969. TYPE: Canada, Saskatchewan, Pike Lake, July 31, 1949, *Boivin, Russell & Breitung 6733* (Holotype: DAO!).

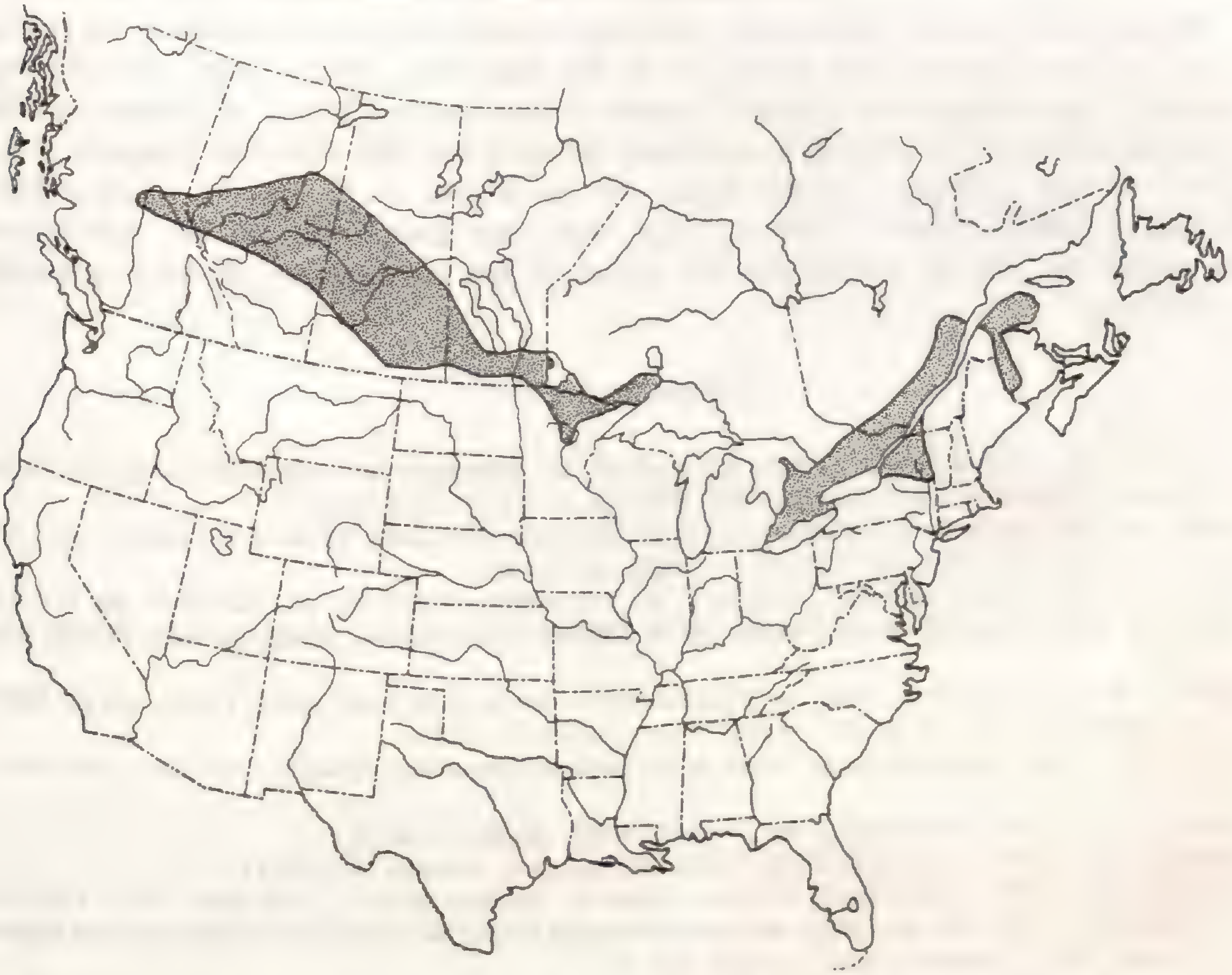

Fig. 3. Distribution of *Anemone virginiana* var. *cylindroidea* in North America.

Base of involucral leaves cordate to reniform; central leaflets variously lobed and toothed, basal margins typically cuneate (sides straight), usually light green to ashen and often silky pubescent. Sepals 5-10 (ave.: 7.2; N = 33) mm long, usually densely tomentose abaxially; anthers 0.7-1.2 (ave.: 0.9; N = 32) mm long; fruiting heads 13-36 (ave.: 19.8; N = 30) mm long, 7-11 (ave.: 8.7; N = 30) mm thick, cylindric. Flowering in early June to early August; fruiting in late July to late August. Herbs of open woods, grasslands, sandy ridges, moist river banks, etc., ranging from eastern Quebec (Gaspé Pen.) and western New Brunswick to southern Quebec and adjacent northern New York, southern Ontario, central Minnesota, and scattered northwestward through the grassland areas of Manitoba, Saskatchewan, and Alberta to central British Columbia (Fig. 3).

With respect to the three varieties of *A. virginiana*, var. *cylindroidea* is closest phenetically to *A. cylindrica* A. Gray. Both *A. virginiana* var. *cylindroidea* and *A. cylindrica* have short sepals with densely tomentose abaxial surfaces and cylindrical fruiting heads. *Anemone cylindrica* usually has >3 involucral leaves, lacks involucels on the secondary peduncles, and in contrast to the greenish styles of *A. virginiana*, has crimson styles. These characters usually separate *A. cylindrica* from *A. virginiana* var. *cylindroidea*, but intergradient forms and rare hybrids sometimes occur, which suggests possible local introgression following the retreat of the last glacial advance.

ACKNOWLEDGEMENTS

We extend our grateful thanks to the following herbaria for loans of specimens and critical types: A, CM, DAO, F, GH, NEBC, NYS, PH, plus ALU, NCU, UNA, and US. We gratefully acknowledge the financial support of the Eberly College of Science of The Pennsylvania State University in underwriting the use of the IBM 3090/180 Computer at the University Park Campus. Special thanks are due to Drs. K. N. Gandhi, Marilyn Park, Ronald A. Pursell, James L. Reveal, Lloyd Stark, and Edward G. Voss for their helpful comments, but we do not impute any errors of fact or judgment to these esteemed colleagues.

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Distribution, Life Forms, Taxonomic Categories, and Habitats of the Endangered and Threatened Vascular Plants in Pennsylvania: A Summary

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Two-thousand and seventy-six plant taxa are known to be native to Pennsylvania, i.e. part of the original flora before settlement by Europeans or occurring due to natural means of dispersal (Rhoads & Klein 1993). This rich flora is the result of a diversity of habitats. For example, Pennsylvania contains the southern extent of the northern hardwood forest and the northern extent of the mixed mesophytic forest (Küchler 1964). Physiographically, Pennsylvania includes a portion of the Coastal Plain in the southeast and the Central Lowland in the northwest (Pennsylvania Geological Survey 1962; Fig. 1). Furthermore, several geological substrates (e.g. limestone, serpentine, shale) support endemic taxa.

The state of Pennsylvania maintains a list of plants of special concern. Of the 2076 native plants, 15% are officially classified as endangered (E) or threatened (T) and 5% are extirpated. Another 9% are rare, vulnerable, or tentatively undetermined. Of these, 6 taxa are listed and 37 are candidates for listing on the Federal Endangered and Threatened Species List (Pennsylvania Natural Diversity Inventory 1993). Two Pennsylvania plants are considered extinct throughout their ranges (Kirkland et al. 1990): *Elodea schweinitzii* and *Micranthemum micranthemoides*. *Elodea schweinitzii* has only been collected in New York in 1816 and in Pennsylvania between 1829 and 1832; however, its taxonomic status is questionable (Cook & Urmi-König 1985). *Micranthemum micranthemoides* was found in freshwater tidal shores from New York to Virginia (Fernald 1950).

I evaluated the known occurrences of the E and T taxa in the state with respect to glaciation and physiographic provinces. Distribution within the state was compared to the total geographic range of the taxon to determine if its occurrence in Pennsylvania was endemic, disjunct, or peripheral. The biological aspects examined included life form and taxonomic relationships. Lastly, I classified the habitat type in which each taxon was found. Brenner (1986) evaluated the distribution and habitats of the E plants in Pennsylvania; however, no comparison to this study is made since only 21 taxa were listed as E at that time and almost all of these are included in this study.

METHODS

The taxa of vascular plants listed as E (227) and T (77) in Pennsylvania constitute the data set for this study (Pennsylvania Natural Diversity Inventory 1993; Rhoads & Klein 1993). Data on distribution in Pennsylvania in relation to Wisconsinan Glaciation (Fig. 1), occurrence in physiographic provinces (Fig. 1), life form, and taxonomic category were tabulated from information in Rhoads & Klein (1993).

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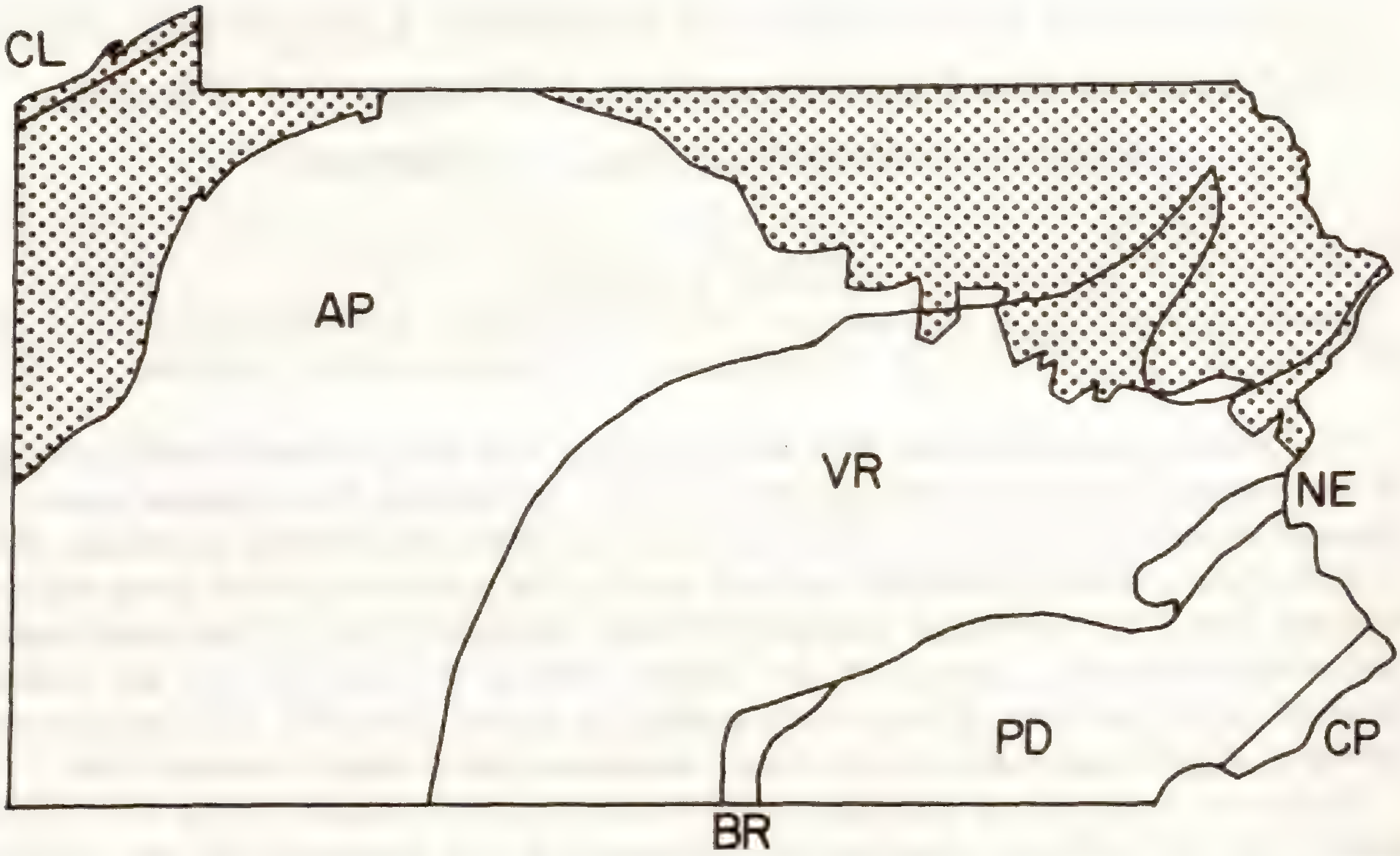

Fig. 1. Physiographic Provinces in Pennsylvania: Central Lowland (CL), Appalachian Plateaus (AP), Valley and Ridge (VR), Blue Ridge (BR), New England (NE), Piedmont (PD), and Coastal Plain (CP). Shaded area represents land covered by Wisconsinan Glacier. Modified from Pennsylvania Geological Survey (1962, 1981). Physiographic boundaries and names are not those currently used by the Pennsylvania Geological Survey.

Data on the total geographic range and habitat were compiled from regional and state floras, taxonomic monographs, and other research papers. The area of each physiographic province in Pennsylvania was determined by weight of paper/area relationship (total area = 117,413 km^2, United States Geological Survey 1970).

A comparison was made between the distribution of each taxon in Pennsylvania (Rhoads & Klein 1993) and the total geographic range of the taxon to determine which of the following categories was most appropriate:

Disjunct. Taxa whose main ranges lie considerably distant from Pennsylvania and do not occur in an adjacent state.

Peripheral from the north. Taxa that range from Newfoundland to Alaska and south to northern Pennsylvania (e.g. *Carex aurea*).

Peripheral from the east. Taxa that occur from Newfoundland or Long Island south to Florida along the coast, west to Texas, and north in the interior to Kentucky and Missouri (e.g. *Ptilimnium capillaceum*). These taxa have occurrences in eastern and southeastern Pennsylvania. The ranges in the northeast of a few of these taxa extend inland from the Atlantic Coast to the Great Lakes (e.g. *Ammophila breviligulata*), and these taxa have occurrences in northwestern and/or southeastern Pennsylvania.

Peripheral from the south. Taxa that occur from southern New Jersey to southern Illinois to Florida and Texas. Some of these taxa have a restricted range: coastal plain taxa that reach their northern limit in southeastern Pennsylvania (e.g. *Arnica acaulis*) and southern Appalachian taxa that reach their northern limit in southcentral and southwestern Pennsylvania (e.g. *Cymophyllus fraseri*).

Peripheral from the west. Taxa that range from southern Ontario to Montana south to western Pennsylvania, western Tennessee, and Kansas (e.g. *Diarrhena obovata*).

Continuous. Taxa whose main ranges include Pennsylvania. Some are northern plants that occur in the southern Appalachians at high elevations (e.g. *Potentilla tridentata*).

Habitat types were divided into six categories:

a. Still or flowing water.
b. Wet, open canopy (e.g. tidal to freshwater marshes and shores, boggy swales, bog mats, fens).
c. Wet, closed canopy (e.g. shrub fens, swamps, alluvial bottomlands).
d. Dry, open canopy (e.g. glades, prairies, dunes and dry shores, fields, savannas).
e. Dry, closed canopy (e.g. shrub thickets, xeric to mesic coniferous and deciduous forests).
f. Cliffs.

The most frequently mentioned habitat was selected for a taxon for which several habitats were listed.

RESULTS

GLACIAL RELATIONSHIP. Fifteen percent of the E and T taxa occur only in the glaciated portions of the state, while 48% are restricted to areas south of the glacial boundary. The remaining 37% show no relationship to glaciation.

PHYSIOGRAPHIC PROVINCES. Eleven percent of the E and T taxa occur only in the Valley and Ridge Province, 11% are restricted to the Appalachian Plateaus, and 7% to the Piedmont. The Coastal Plain and Central Lowland contain 5% and 4%, respectively. None of the E and T taxa occur exclusively in the Blue Ridge or New England Provinces. On a taxa/area basis, the Coastal Plain and Central Lowland had the greatest concentration of E and T taxa restricted to a single province (Table 1).

TABLE 1. Number-area relationships of E and T plant taxa restricted to a single physiographic province in Pennsylvania.

Physiographic Province	Area* (km^2)	# restricted taxa	taxa/area ($\#/km^2 \times 10^{-3}$)
Appalachian Plateaus	68985	35	0.51
Blue Ridge	803	0	0
Central Lowland	575	11	19.13
Coastal Plain	596	14	23.49
New England	643	0	0
Piedmont	12012	22	1.83
Valley and Ridge	33796	33	0.98

*Determined by weight of paper/area relationship given the area of the state as 117,413 km^2 (U.S. Geological Survey 1970).

The remaining 62% of the E and T taxa have occurrences in more than one province, but none have occurrences in all seven provinces. Most taxa occur in adjacent provinces, with the Appalachian Plateaus and Valley and Ridge the most common combination. Several other taxa have occurrences in disjunct provinces; the most extreme being two that occur in diagonally opposite corners of the state, in the Central Lowland and Coastal Plain.

TOTAL GEOGRAPHIC RANGE RELATIONSHIP. *Cerastium arvense* var. *villosissimum* had been considered endemic to Pennsylvania until its recent discovery in Maryland (Latham 1993). Three E and T taxa are disjunct: *Montia chamissoi* (Rhoads et al. 1985), *Aster depauperatus* (included in *A. parviceps*—Hart 1990), and *Carex geyeri* (Keener & Park 1986). An additional disjunct taxon could be *Dodecatheon amethystinum* (Klotz & Walck 1993); however, most populations in Pennsylvania are too variable to separate reliably from *D. meadia* (Klotz & Walck 1993; Rhoads & Klein 1993).

Twenty-eight percent of the E and T taxa are peripheral from the north, 22% from the south, 22% from the east, and 5% from the west. Twenty percent of the taxa have a continuous distribution.

LIFE FORM. Seventy-five percent of the E and T taxa are herbaceous polycarpic perennials, 10% are annuals, and six taxa are biennials/monocarpic perennials. Seven percent are deciduous shrubs, and three taxa are evergreen shrubs. Seven taxa are deciduous trees, one taxon is an evergreen tree, five taxa are herbaceous perennial vines, and one taxon is a woody vine.

TAXONOMIC CATEGORY. Forty-five percent of the E and T taxa are monocotyledons, 51% are dicotyledons, and 4% are pteridophytes. The E and T taxa belong to 76 families; those with the greatest number (greater than 7) are Cyperaceae (65), Poaceae (26), Asteraceae (25), Orchidaceae (14), Potamogetonaceae (10), Ranunculaceae (10), Juncaceae (9), and Rosaceae (8). Of the 171 genera represented on the E and T list of plants, *Carex* (32), *Eleocharis* (11), *Potamogeton* (10), and *Juncus* (9) contain the largest concentrations of E and T taxa. Thirty-one families and 125 genera are represented by only one taxon.

HABITAT. Thirty-seven percent of the E and T taxa occur in wet, open canopy; 23% in dry, open canopy; 18% in dry, closed canopy; 11% in wet, closed canopy; 8% in still or flowing water; and 3% on cliffs.

DISCUSSION

Seventy-seven percent of the E and T taxa in Pennsylvania are at the periphery of their total geographic range. Further, the Wisconsinan Glacial boundary is the limit of the northern distribution of half of the E and T taxa in Pennsylvania. In North Carolina, U.S.A. (Bostick 1981); Massachusetts, U.S.A. (Field 1979); Ontario, Canada (Argus 1992); Finland (Lahti et al. 1991); and Sheffield, England (Hodgson 1986) the majority of rare plants are at the limits of their range. Argus (1992) has argued from biological, social, and political views for the preservation of peripheral populations; however, his most compelling reason is genetic differentiation of peripheral populations.

The Valley and Ridge and Appalachian Plateaus Provinces have the highest concentration of E and T taxa restricted to a single province. This is probably associated with the larger area of the provinces (Table 1), greater diversity of habitats, and a greater representation of distributional patterns. Both provinces have taxa represented in each of the habitat types outlined above with the majority of taxa in four habitat types (ca. 14 taxa for each except cliffs and still or flowing water). Each of the other provinces do not have taxa represented in two or four habitat types, and the majority of taxa only occur in one habitat type (ca. 11 taxa in each province), e.g. wet, open canopy in Coastal Plain and Central Lowland and dry, open canopy in the Piedmont. Furthermore, the Valley and Ridge and Appalachian Plateaus Provinces have taxa represented in all distributional categories; whereas, the other provinces do not have E and T taxa represented in two or three categories. Davis (1993) found a similar physiographic pattern for E and T wetland plants in Pennsylvania.

Seventy-seven percent of the E and T taxa are herbaceous polycarpic perennials (including herbaceous perennial vines), which is not unexpected since the majority of plants in northern North America (Thieret 1977) and Pennsylvania (Rhoads & Klein 1993) are herbaceous perennials. Furthermore, 12% are annuals or biennials/monocarpic perennials, 8% are shrubs, 3% are trees, and one taxon is a woody vine. These percentages about equal the percentages of the life forms among the native taxa in Pennsylvania (Rhoads & Klein 1993). A similar pattern has also been found for the rare plants in New England (Field 1979).

In Pennsylvania, 5% of the total native flora are pteridophytes, 1% are gymnosperms, 33% are monocotyledons, and 61% are dicotyledons (Rhoads & Klein 1993). These percentages are about equal to those for the northeastern United States: 3%, 1%, 28%, and 68%, respectively (Fernald 1950). However, 45% of the E and T taxa are monocotyledons and 51% are dicotyledons, and none is a gymnosperm. Field (1979) found a similar pattern for rare plants in New England.

Families with the largest number of E and T taxa are also the largest families in Pennsylvania and the northeastern United States, namely the Cyperaceae, Poaceae, and Asteraceae (Fernald 1950; Rhoads & Klein 1993). The Rosaceae, the fourth largest family in Pennsylvania and the northeastern United States (Fernald 1950; Rhoads & Klein 1993), is underrepresented in number of E or T taxa. *Carex* is the largest genus in Pennsylvania (Rhoads & Klein 1993).

Fifty-seven percent of the E and T taxa in Pennsylvania are associated with water-dependent habitats and 43% with dry habitats. Further, most of the E and T taxa in Pennsylvania are associated with open canopy habitats; a result also obtained for New England (Field 1979). In a recent study, Davis (1993) reported that 57% of the 579 species listed as "Plants of Special Concern in Pennsylvania" were wetland species. Thus, the majority of the E and T taxa in Pennsylvania occur in water-dependent habitats, which occupy about 2% of the state's land surface (Tiner 1989).

ACKNOWLEDGMENTS

I thank A.E. Schuyler, J. and C. Baskin, and A.F. Rhoads for advice and for reviewing the manuscript; and K. Fogarasi for computer assistance. I especially thank Virginia D. Einwechter for her warm hospitality during my stay in Philadelphia.

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Bartonia No. 59: 55-70, 1996

The Genus *Rhexia* in New Jersey

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Rhexia is a small North American genus of 13 recognized taxa (11 species, 2 varieties; fide Kral & Bostick 1969). The majority of the taxa occur on the Coastal Plain of the southeastern United States (James 1956; Kral & Bostick 1969), which is the region of greatest taxonomic complexity. This complexity results from variation within taxa and hybridization between taxa (James 1956; Kral & Bostick 1969). In New Jersey the genus is represented by five taxa: *Rhexia aristosa, R.* × *brevibracteata* (here named and described), *R. mariana* var. *mariana, R. mariana* var. *ventricosa*, and *R. virginica.* The distribution of the genus within New Jersey mirrors the distribution of the genus as a whole: only one taxon is widespread in the state, the other taxa are restricted to the Coastal Plain and reach their greatest abundance and diversity in the southernmost portion of that province. Cape May is the only county containing all the taxa of specific or subspecific rank.

In New Jersey material, the taxonomical distinctions between the taxa are normally sharp, and they usually can be distinguished readiliy in both the field and herbarium. When identification difficulties are encountered, these invariably involve distinguishing *R. mariana* var. *ventricosa* from either *R. mariana* var. *mariana* or *R. virginica*, and *R. aristosa* from *R. virginica.* The difficulty with *R. mariana* var. *ventricosa* is largely an herbarium problem, a result of trying to put a name to incomplete or poorly prepared herbarium material. It can be rectified by collecting only complete and fully mature specimens which are accompanied with good field notes. Identification of *R. aristosa* and *R. virginica* is apparently complicated by hybridization of the two taxa, at least there are morphologically intermediate specimens between these otherwise discrete taxa. Natural hybrids involving various combinations of *R. mariana* var. *mariana, R. mariana* var. *ventricosa*, and *R. virginica*, have been reported (James 1956; Kral & Bostick 1969), but none of these have been confirmed from New Jersey. Occasionally specimens are encountered that are difficult to place, and hybridism is a possibility, but this is not easily verified from a study of herbarium specimens, especially when the collection is represented by a single specimen lacking detailed field notes. When collecting in this genus, it is important to note if other taxa of *Rhexia* are present, and if the specimen collected is representative of the population instead of an aberrant individual. In cases where morphological variation or intermediacy is observed, a representative series of specimens should be collected.

The taxonomy and distribution of *Rhexia* in New Jersey has not been discussed previously in any significant detail. In the early catalogs and floras of Britton (1889), Stone (1912), and Taylor (1915), the distribution, abundance, and habitat is summarized for the three taxa then known to occur in New Jersey (*R. aristosa, R. mariana, R. virginica*). County distribution maps and terse comments are presented in Hough (1983) for the same taxa. The purpose of this paper is to update and clarify the distribution, more fully describe habitat and biology, and to describe the taxa within the framework of current taxonomic concepts. Specimen citations are primarily based on specimens at CHRB, GH, NY, PH, and my own collection (DBS). Nomenclature follows Kartesz and Kartesz (1980).

KEY TO NEW JERSEY *RHEXIA*

1. Rootstocks not tubiferous, usually shallowly set, stiff, horizontally spreading, freely rhizomatous, and wide creeping (if characters of rootstocks are unavailable, go to heading 3) 2
    2. Stem faces unequal, one pair of opposing faces broader and convex, the other, much narrrower and concave, stems appearing cylindrical at mid stem, flowers pink, to almost white . . . . 1. *R. mariana* var. *mariana*
    2. Stem faces all approximately equal, stems appearing square at mid stem, flowers (normally) rose to magenta . . . . 2. *R. mariana* var. *ventricosa*
1. Rootstocks tuberiferous (or at least some plants within the population producing tubers), soft and flexible, rhizomes when produced, soft and flexible 3
        3. Stem faces unequal, one pair of opposing faces broader and convex, the other much narrrower and concave, stems appearing cylindrical at mid stem, stem angles not winged; flowers pink to almost white . . . . 1. *R. mariana* var. *mariana*
        3. Stem faces all approximately equal, stems appearing square at mid stem, angles winged or not winged; flowers (normally) rose to magenta 4
            4. Inflorescence leafy bracted, the leaves only gradually reduced and not at all scale-like; sepal lobes linear to narrowly lanceolate, at maturity 4-7 mm long, tipped with a stout, eglandular awn, ± 1 mm long; hypanthium rim beset with coarse, yellowish trichomes 2.5 mm or more long (often as long as the calyx lobes); surface of seeds longitudinally ridged, the concentric ridges relatively broad, low, smoothish to somewhat verrucosely margined, continuous or a series of contiguous low domes, the surface appearing merely wrinkled or pebbled at low magnification . . . . 4. *R. aristosa*
            4. Inflorescences not leafy bracted, appearing naked, the uppermost bracteal leaves greatly reduced or scale-like and many times shorter than the mature hypanthium; sepal lobes deltoid to lanceolate, at maturity 1-4.3 mm long, tipped with a slender, usually gland-tipped hair 0.5-1 mm long; hypanthium rim with or without coarser yellowish trichomes, when present 2.0 mm or less long and shorter than the sepal lobes; surface of seeds muricate or papillose, with or without low, smoothish, domes or ridges, the processes forming nearly concentric, longitudinal, relatively narrow and high rows or ridges, surface appearing more granular than wrinkled at low magnificaition 5
                5. Surface of seeds finely papillose, the projections forming, neat, low, closely concentric ridges, without a well developed dorsal crest . . . . 2. *R. mariana* var. *ventricosa*
                5. Surface of seeds muricate or coarsely papillose, the ridges more irregular and less closely concentric, with or without a well developed dorsal crest 6
                    6. Stems conspicuously winged (wings usually more than 0.25 mm); sepal lobes short, mostly 2.5 mm or under, deltoid or lanceolate; hypanthium rim without coarse yellowish trichomes 3. *R. virginica*
                    6. Stems wingless or only inconspicuously winged (wings mostly 0.25

mm or less); sepal lobes longer, 2.1-4.5 mm; hypanthium rim beset with coarse, yellowish, trichomes . . . . 4. *R.* × *brevibracteata*

1. **Rhexia mariana** L. var. **mariana**.

This is the only taxon in *Rhexia* occurring in New Jersey that does not have a square stem. Although the stem is not truly cylindrical, the combination of concave and convex opposing faces give it the appearance of being round, and it rolls easily when pushed lightly between thumb and forefinger. When in flower, it is easily recognized by its pale pink (rarely darker) to nearly white petals, all other taxa being rose colored, varying to crimson or magenta. Although the taxon is variable in a number characters (Fernald 1950; James 1956; Kral & Bostick 1969) throughout its range, New Jersey material is fairly uniform, especially in leaf shape and vestiture. Leaves are predominantly elliptic, frequently narrowly so, and hirsute above and on the veins below. The stem is also hirsute, giving the plant its characteristic bristly appearance.

It is common, and occurs on the Coastal Plain from Massachusetts south to southern Florida, then west to Texas. In the interior it occurs from Georgia to Virginia, and northwest to Missouri, Illinois, and Indiana (James 1956; Kral & Bostick 1969).

Rhexia mariana var. *mariana* is frequent in the southern portion of New Jersey, and after *R. virginica*, it is the secondmost common *Rhexia* occurring in state. It has been collected from all Coastal Plain counties, except for the two northernmost, Mercer and Middlesex. Although widespread throughout this region, it tends to be somewhat local in its distribution, reaching its greatest abundance in Atlantic and Cape May counties and in portions of the counties bordering the Delaware bayshore. Since it spreads by a system of horizontally creeping, rhizomatous rootstocks, it is usually abundant where found and forms extensive colonies.

It grows in a variety of mostly successional habitats which are at least seasonally wet and is commonly found in moist sandy or peaty thickets, moist shallow depressions and shoulders of roadsides and trails through pitch pine lowland forests, meadows, moist fields, upper peaty shores of ponds, and occasionally sphagnous wetlands. Its stoloniferous habit makes it weedy, and therefore a good colonizer, and it can be found abundantly in railroad and powerline right-of-ways, bottoms of inactive sand pits, banks of ditches, and other disturbed habitats. It is the least likely taxon in *Rhexia* to be found in permanently saturated soils or standing water in New Jersey.

Flowering is from early July (rarely earlier) into mid October. The foliage turns bright orange or red-orange in the Autumn, with the leaves persisting late into the season, and usually not falling until after a hard frost.

This is a distinctive species and readily identifiable in the field and herbarium, unless specimens are incomplete or poorly prepared. In which case, specimens may be confused with *R. mariana* var. *ventricosa*.

REPRESENTATIVE NEW JERSEY SPECIMENS EXAMINED. **Atlantic Co.**: Moist open sandy soil near Great Egg Harbor River, W of English Creek, 30 Aug 1933, *W. M. Benner 5388*, PH. **Burlington Co.**: Sphagnous bog near Fisher Branch, Crosswicks Creek ca 2.5 mi S of Cookstown, 8 Jan 1951, *B. Long 70764*, PH. **Camden Co.**: 2 mi S of Clementon, 3 Sep 1939, *L. P. Hynes 1440*, PH. **Cape May Co.**: Swale along Crooked Creek, E of Cape May Court House, 11 Sep 1938, *B. Long 53070*, PH. **Cumberland Co.**: Old cart road through woods SE of Haleyville, 10 Aug 1933, *B. Long 41496*, PH. **Gloucester Co.**: Edge of low sandy thicket ca 1 mi NW of Bridgeport, 13 Feb 1949, *B. Long 68712*, PH. **Monmouth Co.**: 1.5 mi W of Fort Plains, 4 Aug 1955, *V. L. Frazee s. n.*, PH. **Ocean Co.**: Wet meadows very near the salt marshes, Coxs, E of Tuckerton RR and the Shore Road, 11 Oct 1910, *B. Long 5480*, PH. **Salem Co.**: Sandy peaty border of pond-hole, 1.5 mi NNE of Olivet, 6 August 1935, *B. Long 47092*, PH.

2. **Rhexia mariana** L. var. **ventricosa** (Fern. & Grisc.) Kral & Bostick

This taxon possesses the unique combination of square stems and stoutish, horizontally creeping and freely rhizomatous rootstocks that are not tubiferous. Only *R. mariana* var. *mariana* has similar rootstocks but its stem is distinctly subcylindrical. The remaining New Jersey taxa are all square stemmed with tubiferous rootstocks. While *R. mariana* var. *ventricosa* never produces tubers, it can not be said that all plants within populations of *R. virginica* or *R. aristosa*, will have tubers. However, at least some plants within the population will be tuberiferous, unless all are very young. When tubers are not present (or not collected) the rootstocks of *R. virginica* and *R. aristosa* usually differ from *R. mariana* var. *ventricosa* by being softer (spongy thickened when growing in standing water), more clustered, commonly descending, and therefore more deeply set. In contrast, those of *R. mariana* var. *ventricosa* are more woody and therefore stouter and less flexible; they spread horizontally just below the surface of the soil and are freely rhizomatous. *Rhexia virginica* and *R. aristosa* occasionally produce long creeping roots and even rhizomes, but these are never woody or stout. Surface sculpturing of mature seeds of *R. mariana* var. *ventricosa* is distinctive and is usually diagnostic (see discussion under *R. virginica*). The seeds are finely papillose with concentric rows of closely and evenly spaced papillae, and lack a well developed dorsal crest. Seeds of all other taxa are either muricate, coarsely and irregularly papillose, verrucose, or smooth ridged. In absence of rootstocks and mature seeds, it is sometimes difficult to distinguish *R. mariana* var. *ventricosa* from *R. virginica*. In such situations, the two taxa can usually (but not infallibly) be separated by the lack of a well developed wing on the stem of *R. mariana* var. *ventricosa*, and by the length of the hypanthium neck relative to the length of its body: in *ventricosa* the neck is equal to or longer then the body; in *virginica* the neck is predominantly shorter then the body (James 1956; Kral & Bostick 1969). If care is taken in collecting complete specimens with mature fruit, and if the specimens are then prepared so that stem characteristics are not lost in pressing (i.e. using foam rubber pads between the blotters and cardboard ventilators), *R. mariana* var. *ventricosa* can be easily and reliably identified.

Somewhat local in distribution, *R. mariana* var. *ventricosa* is restricted to the eastern United States where it occurs on the Coastal Plain from southern New Jersey to South Carolina (James 1956; Kral & Bostick 1969).

In New Jersey, *R. mariana* var. *ventricosa* is apparently restricted to the Cape May peninsula where it is documented from five extant localities and two historical sites from Cape May north to Cape May Court House. Although recently rediscovered in New Jersey (Snyder 1994), preliminary field investigations suggest that it may not be exceptionally rare, but perhaps overlooked and undercollected. *Rhexia mariana* var. *ventricosa* was first reported as occurring in New Jersey by James (1956) based on specimens collected from Cape May by Mackenzie in 1909 (Snyder 1994). In 1991, Andy Windisch and I discovered a large population just north of Kay's Pond (Snyder 1994). Subsequently, I located one additional herbarium specimen (*Brown s. n.* CHRB) and four additional occurrences in the field. Whether this taxon is restricted to Cape May County or more widespread remains to be seen after more searching. Unless specifically searched for, it is easy to pass over *R. mariana* var. *ventricosa* for *R. virginica*. This may be why the species has gone largely unrecognized in the state until now. It may be too, that this is example of southern taxon expanding its range northward.

All documented extant occurrences of this variety are in sandy soils of open, or somewhat thicket-covered, inactive sand pits located within oak-pine or oak dominated forests. These pits all have seasonally fluctuating water levels, and in this respect function much like Coastal Plain intermittent ponds. Some characteristic associated plant species include *Eleocharis quadrangulata*, *Spiranthes odorata*, *S. vernalis*, *Rotala ramosior*, and *Hedyotis uniflora*. Like *R. mariana* var. *mariana*, var. *ventricosa* tends to be weedy, and successfully exploits disturbed habitats. Apparently only Mackenzie's 1909 specimens (*4438* NY) labeled "moist meadow" were collected in what could be a natural habitat.

Flowering occurs from mid July into mid October. The foliage turns a brilliant yellow-orange in the Autumn, with the leaves persisting late into the season, and usually not falling until after a hard frost.

This taxon has been recognized at the specific level by Fernald (1935; 1950) and James (1956), reduced to subspecific rank by Kral & Bostick (1969), and most recently, subsumed under *R. interior* by Cronquist (Gleason and Cronquist 1991). Although a distinctive and easily recognized taxon, *R. mariana* var. *ventricosa* suggests an intermediate between *R. mariana* var. *mariana* and *R. virginica*. It has the stout, horizontally spreading rhizomatous rootstocks and the long necked hypanthia of *R. mariana* var. *mariana* but the square stems and the generally more ovate shape of its leaves are characters of *R. virginica*. This intermediacy led James (1956) to speculate that *R. mariana* var. *ventricosa* may be of hybrid origin with *R. mariana* var. *mariana* and *R. virginica* the putative parents. However, Kral & Bostick (1969) noted that the hybrid between these taxa was quite different. Further, chromagraphic, cytologic, and morphologic studies conducted by these authors showed that *ventricosa* bore a much closer relationship to typical *mariana* then it did to *R. virginica*, thus supporting the reduction of *ventricosa* to varietal level under *mariana* (Kral & Bostick 1969). Although artificial hybrids between *R. mariana* var. *ventricosa* and both *R. mariana* var. *mariana* and *R. virginica* have been produced experimentally (Kral & Bostick 1969), naturally occurring hybrids between these taxa apparently have not been observed (James 1956; Kral & Bostick 1969).

REPRESENTATIVE NEW JERSEY SPECIMENS EXAMINED. **Cape May Co.**: Moist meadow, Cape May, 18 Sep 1909, *K. K. Mackenzie 4438*, NY; Damp soil, Cold Spring, 25 Aug 1936, *O. H. Brown s. n.*, CHRB; Extensive colony growing in moist sand of inactive sand pit, Pierces, 0.4 mi NW of Kay Pond, 15 Oct 1991, *D. Snyder* and *A. Windisch*, CHRB, DBS, PH, VDB; Common in wet sandy soil in thickets and open, sedgy bottoms of inactive sand pit, Higbee Beach, 0.4 mi NE of Davey's Lake, 29 July 1992, *D. Snyder*, CHRB, DBS; Scattered colonies in moist to wet sand in thickets and more open areas of excavated portions dredge spoil bank, Petticoat Bridge, just SE of North Cape May, 29 Jul 1992 and also 5 Oct 1992, *D. Snyder*, CHRB, DBS; Large, scattered colonies in moist to saturated sandy bottoms of a series of inactive sand and gravel pits, just NNW of Cold Spring, 29 Jul 1992 and also 5 Oct 1992, *D. Snyder*, DBS, PH; Extensive colony in moist, sandy edge of thicket in partially regraded and filled sand pit along eastern edge of Goshen Sports Complex, ca 1 mi N of Cape May Court House, 30 July 1992, *D. Snyder*, DBS.

3. **Rhexia virginica** L.

This species is easily distinguished from all other New Jersey taxa by its conspicuously wing-angled stems. The wings are usually prominent, but they can be as narrow as 0.25 mm (James 1956). Wings near the minimal width are often obscured in pressing, so it best to observe this character on living specimens. In general aspect, *R. virginica* closely resembles *R. mariana* var. *ventricosa*, however, the rootstocks of the former are not tuberiferous, while those of *R. virginica* are commonly tuberously thickened. Since the tubers are easily detached, many herbarium specimens lack tubers. Additionally, the tuberous thickenings are relatively short-lived and eventually degenerate and may persist for as little as one year (Posluszny et al. 1984). A number plants may have to be examined before the tuberiferous rootstock is observed. The seeds of *R. virginica* are usually sharply distinct from *R. mariana* var. *ventricosa*, the surface being irregularly ridged, the processes being muricate or coarsely papillose, with those of the dorsal crest being coarser and better developed, in contrast to the uncrested, fine, and neatly rowed papilliae of *R. mariana* var. *ventricosa*. Seed morphology of *R. virginica* is quite variable, and while most fit the previous description, specimens vary from nearly tuberculate to merely papillose. Exceptional specimens that I collected from the edge of a water filled sand pit near Big Goose Pond, Egg Harbor City, Atlantic County (7 Oct 1993, *Snyder* DBS), had seeds which were finely papillose with the processes of the dorsal crest only slightly more coarse, and essentially indistinguishable from seeds of *R. mariana* var. *ventricosa*. However, the roots of these specimens were tuberously thickened and the necks of the hypanthia were distinctly shorter than their bodies, both characteristics of *R. virginica*.

This is the most widespread and most common species of *Rhexia*. It occurs from southern Canada south to northern Florida, and west to Missouri, Iowa, and eastern Texas (James 1956; Kral & Bostick 1969).

Rhexia virginica is also the most abundant and most widely distributed taxa occurring in New Jersey. It reaches its greatest abundance in the Coastal Plain, especially within the Pine Barrens, and occurs sporadically northward, mostly in the Piedmont, to Hunterdon, Morris, Passaic, and Bergen counties.

It grows in a diversity of open, mostly acidic, wetland habitats including pine barren savannas, shores and shallow bottoms of Coastal Plain intermittent ponds, swampy woods, peaty or sandy thickets, seepage areas along small streams, edges of Atlantic white cedar swamps, and meadows. It is frequently associated with sphagnum mosses. Although this species is not especially weedy, it occurs abundantly in disturbed or successional habitats such as abandoned cranberry bogs, ditches, fields, inactive sand and gravel pits, and also powerline, railroad, and road right-of-ways. In northern New Jersey it has been collected from seasonally moist, open thickets over trap rock. When growing in permanently saturated soils or in standing water, the stems and rootstocks become spongy-thickened.

Flowering is from early July into late September, rarely later. The foliage turns deep red to red-purple in the Autumn. It is the first *Rhexia* to loose its leaves in the Autumn, which commonly drop shortly after flowering has ceased, and seeds have matured, which is often well before the onset of a hard frost. From late September through mid October, when the foliage of other taxa of *Rhexia* is green or only beginning to reveal Autumnal colors, plants of *R. virginica* are conspicuous with their often bare stems and dehiscent capsules (Snyder 1994).

My treatment of *R. virginica* is sensu James' (1956) *R. virginica* var. *virginica* and excludes the var. *purshii* (Spreng.) James. The var. *purshii* is a southern element, perhaps ecotypic (R. Kral pers. comm.), that occurs from North Carolina south to Florida, then west to Mississippi (James 1956). It is distinguished from the typical variety by its nearly glabrous stems, narrower and typically lanceolate leaves, longer sepal lobes (up to 4 mm), and smaller, usually glabrous hypanthia. In its extreme, it is distinctive, but intermediates are frequent, and for this reason the variety is usually subsumed under *R. virginica* (Kral & Bostick 1969; Kral pers. comm.). My reason for following James' circumspection is strictly one of convenience. As noted by James (1956), some of the morphological characters of var. *purshii* approach those of *R. aristosa*. Since var. *purshii* has not been documented for New Jersey, I feel that it is unnecessary to complicate key construction by including the full spectrum of rangewide variations of *R. virginica*.

Experimentally produced, as well as naturally occurring hybrids between both varieties of *R. mariana* and *R. virginica* have been reported (James 1956; Kral & Bostick 1969), but these hybrids have not been documented for New Jersey. Fertile hybrids between *R. aristosa* and *R. virginica* have been produced experimentally (Kral & Bostick 1969) and specimens of what have been determined as naturally occurring hybrids between these taxa have been reported (James 1956; R. Kral pers. comm.). See comments under *R. aristosa* for further discussion.

REPRESENTATIVE NEW JERSEY SPECIMENS EXAMINED. **Atlantic Co.**: Common on black sphagnous peat of large clearing in cedar-birch-cranberry, petals lavender-rose, 6 mi NW of Tuckahoe, 10 September 1964, *R. Kral 22620*, PH. **Bergen Co.**: Moonachie, near Losen Slofe Branch of Hackensack River, 22 JUL 1970, *W. Sipple 1593*, PH. **Burlington Co.**: Bog ca 3 mi S of Cookstown, 15 Aug 1950, *B. Long 72007*, PH. **Camden Co.**: Open swamp along Pump Branch of Albertson Brook, Ancora, 28 Aug 1926, *J. W. Adams 504*, PH. **Cape May Co.**: Swamp ca 1 mi SW of Marshallville, 29 Aug 1946, *W. M. Benner 10241*, PH. **Cumberland Co.**: Dam breast of old cranberry bog on Panther Rd., ca 1 mi SE of Coopers Mill, 18 May 1946, *B. Long 64879*, PH. **Gloucester Co.**: Sandy, peaty margin of pond on Little Ease Run, Franklinville Lake, Franklinville, 25 Jul 1940, *B. Long 54868*, PH. **Hunterdon Co.**: Lambertville, 1887, J. H. Butterfoss *s. n.*, PH. **Mercer Co.**: Princeton Junction, 19 Aug 1894, *T. Seal s. n.*, PH. **Middlesex Co.**: Along path in moist woods between Riva Avenue and Farrington Lake, S of Church Lane, Patrick's Corner, 11 Aug 1983, *J. S. Meyer, et al. s. n.*, CHRB. **Monmouth Co.**: Swampy woods, 1 mi N of Fort Plains, 1 Aug 1955, *V. L. Frazee s. n.*, PH. **Morris Co.**: Sandy bog, MT. Tabor, 19 Aug 1920, *K. K. Mackenzie s. n.*, NY. **Ocean Co.**: *Chamaecyparis* bog, Warren Grove, 1 Aug 1941, *R. H. Pohl 3227*, PH. **Passaic Co.**: Moist, open thicket on trap rock hillside, Garrett Mountain Reservation, 13 Aug 1992, *D. Snyder*, DBS. **Salem Co.**: Sphagnous border of pond-hole along intermittent streamlet, ca 1 mi E of Union Grove, 4 Sep 1937, *B. Long 51453*, PH. **Somerset Co.**: Local on RR track, W of Middlebush, 8 Jul 1945, *M. A. Chrysler s. n.*, CHRB. **Union Co.**: Terminal moraine behind Jefferson School, Summit, 6 Aug 1936, *J. Kezer s. n.*, NY.

4. **Rhexia aristosa** Britt.

Rhexia aristosa is characterized by its square, wingless, or essentially wingless stems with glabrous internodes; its nearly glabrous, linear-lanceolate to lanceolate leaves commonly under 6 mm wide (rarely more than 8 mm) with prominent veins below, strongly ascending to almost erect, and gradually reduced in the inflorescence; the bracts often as long or longer than the mature hypanthia; its long (3-7 mm), linear to lanceolate, stiffly awn-tipped sepal lobes; the long (2.5-4.5 mm), coarse, yellowish, eglandular trichomes congested at the rims of the hypanthia; and the seeds with low, more-or-less concentrically arranged, smooth to verrucosely margined ridges or domes, which give them a wrinkled or brain-like appearance. Kral & Bostick (1969) and some subsequent authors (Godfrey & Wooten 1981; Gleason & Cronquist 1991) describe the flowers as being "dull lavender" in contrast to the "bright rose-lavender" color of flowers of *R. virginica.* I have found no significant color difference in side-by-side living plants of *R. aristosa* and *R. virginica* in New Jersey. I would describe both as rose or magenta. Darker or lighter color forms are occasionally encountered in both species.

Rhexia aristosa is extremely local to rare throughout its range. It is restricted to the Coastal Plain in North Carolina, South Carolina, Georgia, and Alabama, with disjunct occurrences in Delaware and New Jersey[1] (The Nature Conservancy Biological and Conservation Database). It reaches its greatest abundance in North Carolina and Georgia (R. Kral, A. Weakley pers. comm.) The species is currently under federal review as being possibly threatened or endangered in the United States (U. S. Fish and Wildlife Service 1990).

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[1] Stalter & Lamont (1990) report collecting a specimen of *R. aristosa* from Assateague Island, Virginia. However this specimen has been reidentified as *R. virginica* (Frank Hirst pers. comm.). Beaven & Oosting (1939) report *Rhexia aristosa* in their paper, "Pocomoke Swamp: A Study of a Cypress Swamp on the Eastern Shore of Maryland" which is misleading since the study site is located in both Delaware and Maryland. *Rhexia aristosa* is identified as occurring in the "Burned Area" which is wholly within Delaware (Bill McAvoy pers. comm.) and is currently known as the Burnt Swamp. There appears to be no documentation supporting a Maryland occurrence of *R. aristosa*.

This is the rarest taxon of *Rhexia* occurring in New Jersey. It is currently documented from three extant occurrences: two contiguous ponds in north central Atlantic County and one site in northern Cape May County. Two additional historical sites are documented from the same general area that the extant Atlantic County occurrences are found. One of these historical sites is the type locality where plants were discovered in 1888 by J. C. Gifford and E. H. Kilmer (Britton 1890). Neither the type (NY) nor the isotypes (GH, NY) contain any specific information on their labels that pinpoints the type locality, and its exact location remains uncertain. Type specimens are labeled "Egg Harbor City"[2] along with subsequent collections by the original collectors except for one labeled "near Egg Harbor" (*Gifford s. n.* PH). Attached to the type specimen is a letter written by E. H. Kilmer to N. L. Britton dated 11 February 1889, which states: "We were at Egg Harbor City (seven miles from [Mays Landing]) and the *Rhexias* attracted our attention as we were walking on the embankment of the railroad. The plants were growing in a narrow ditch-like excavation three feet wide." Between 1888 and 1898, numerous collections were made from "Egg Harbor City," all presumably from the type locality. A second, and apparently new locality, was discovered in 1898 at Cologne, about 2.5 miles southwest of Egg Harbor City (*Saunders s. n.* PH; Stone 1912). Despite diligent field searching (Fables 1962; Hirst & Hirst 1962), *R. aristosa* went undetected for nearly sixty years, until a third locality was discovered in 1957 by Frank and Robert Hirst at Little Goose Pond, southwest of Egg Harbor City (Hirst & Hirst 1962). Little Goose Pond is a natural pond located about a mile southwest of the railroad, and is clearly not the type locality. However, the outlet stream to the pond is crossed by the railroad just to the northwest of Egg Harbor City, and it is conceivable that seeds from Little Goose could have been dispersed into drainage ditches along the railroad. If this was source of the plants discovered at the type locality, it might provide an explanation as to why *R. aristosa* can no longer be found in the drainage ditches along the railroad: the habitat was suitable to briefly support a population, but conditions were inadequate to sustain the population. *Rhexia aristosa* was next collected in 1959 (*R. Hirst s. n.* PH) from a shallow, water filled borrow pit located about 1.5 mile southeast of Egg Harbor City. Although the specimen is labeled "Cologne," it was collected about a mile northwest of that community (F. Hirst pers. comm.). It can not be determined whether this is the same site as C. F. Saunder's 1898 collection, or possibly even the same as the type locality. Repeated searches of the site has failed to relocate the species. In 1982, I found a small population in Big Goose Pond. Big Goose, which is located immediately adjacent to Little Goose, had been thoroughly searched by Frank and Robert Hirst in the late 1950s for *R. aristosa* (F. Hirst pers. comm.), as well as by many others in the intervening years. The species' seemingly abrupt appearance in recent years at Big Goose may be explained by either the presence of dormant seeds in the seed bank, or recently spread seeds by waterfowl, deer, box turtles (present by the dozens buried in the mud one dry summer) or even accidentally introduced as seed stuck on the boots of one of the many botanists that have since visited these ponds. In 1982 this population consisted of a few, scattered plants, but in 1992 I counted ca. 1400 plants. No new locations were documented until 1991 when I discovered a small population in an inactive sand pit near Petersburg, Cape May County.[3]

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[2] Both James (1956) and Kral & Bostick (1969) cite the type locality as "May's Landing, Egg Harbor City, Atlantic Co." The two place names refer to distinct localities separated by about seven miles. The error of citation is no doubt a result of a newspaper article from the 16 Feb. 1889 edition of the May's Landing Record entitled, "May's Landing Adds a New Flower to the Flora of the State" which is attached to the type of *Rhexia aristosa*. The article is written by J. E. Peters who sent the original specimens collected by Kilmer and Gifford to Britton. Peters, who lived at May's Landing, was being overly parochial in his use of "May's Landing" as the name of the collection locality and he does not mention Egg Harbor City anywhere in the article. Kilmer in his letter to Britton clearly states that the specimens came from Egg Harbor City.

In New Jersey, *Rhexia aristosa* is restricted to a very narrow range of habitat types. Habitats of extant occurrences are similar in two respects: all are in wetlands characterized by fluctuating water levels and located in either pitch pine lowland or pine-oak forests within the Pine Barrens. The habitats can be further divided into natural systems and those created or maintained anthropogenically.

Two of the three extant occurrences are in Coastal Plain intermittent ponds. Big and Little Goose ponds are the largest natural ponds occurring in the Pine Barrens. The largest of the two is Big Goose Pond at ca. 22 acres. Water source is either from rainfall or ground water seepage, and drainage is a combination of external (ephemeral streams) and internal (percolation and evaporation). Despite their acreage, the ponds are shallow bottomed, and during years of average precipitation, they largely dry out by mid summer. Surface soils range from sand or sandy loam with no, or only a shallow layer of organic matter, and are underlain by gravelly sand. When dry, the bottoms of the ponds are covered by herbaceous vegetation, with species of grass, sedge, and rush dominating. Characteristic herbaceous species occurring in one or both of these ponds include *Carex striata*, *Cladium mariscoides*, *Rhynchospora fusca*, *R. inundata*, *Scleria reticularis*, *Panicum hemitomon*, *P. verucosum*, *Juncus pelocarpus*, *Xyris difformis*, *X. smalliana*, *Lachnanthes caroliniana*, *Eriocaulon aquaticum*, *Sagittaria teres*, *Drosera intermedia*, *Utricularia juncea*, *U. olivacea*, and *Lobelia boykinii*.

Rhexia aristosa has been documented from two types of artificially created habitats. As previously noted, the type specimens were collected from a drainage ditch along a railroad. The Hirst specimen from Cologne and the recently discovered Petersburg population are from borrow pits. In structure and function these pits are much like natural intermittent ponds. Both of these pits are shallow excavations in sandy soils with fluctuating water levels. Water levels are determined by rainfall and ground water seepage. Drainage is internal or through evaporation. These two borrow pits, as well as numerous other similar ones that occur throughout New Jersey's Coastal Plain, support floras that are similar to those found in their natural counterparts.

There is no evidence that *R. aristosa* is weedy, nor does it seem to readily colonize disturbed or artificially created habitat, or for that matter, natural ponds. Although seed production in *R. aristosa* is prolific, the species is extremely rare throughout most of its range. This suggests that either (or more likely both) the methods of seed dispersal or the availability of suitable habitat are the critical factors limiting the distribution of *R. aristosa.* Seeds could be dispersed into contiguous wetland habitats by water movement, but long range dispersal into noncontiguous habitats presumably is achieved through the movement of animals, most likely by waterfowl, which would likely favor natural ponds or other large water filled depressions such as sand pits.

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[3] Previous reports for Cape May County (Stone 1912; Fairbrothers and Hough 1973) prove to be erroneous. Specimens collected by Gerry Moore (15 Jul 1992 *835*; 19 Jul 1992 *863* PH) from a Coastal Plain intermittent pond SSE of Hunters Mill, Cape May County, New Jersey were initially identified as *R. aristosa* by R. Kral (G. Moore pers. comm.). Specimens that I collected from this population (26 Oct 1992 *s. n.* VDB), were identified by R. Kral as *R . mariana* var. *ventricosa*. Although these late season specimens were rather poor (all stem leaves had dropped and the hypanthia were badly weathered) the mature seeds clearly rules out *R . aristosa*. After studying additional specimens collected by myself in 1993, my tendency is to place them with *R. virginica* based on the tuberously thickened roots, fairly wide leaves (8 mm to 1.4 cm), greatly reduced bracts, the short (ca. 2 mm) sepal lobes, and the relatively slender, short glandular hairs of the hypanthia. However, a few specimens do have narrower leaves and somewhat stouter hairs on the rims of the hypanthia, and in these characters suggest *R.* × *brevibracteata*. A more thorough study of this population is needed to resolve its identification.

Rhexia aristosa's occurrence in disturbed habitats is infrequent throughout its range and such occurrences may be short lived. Rather than colonizing disturbed habitats, it is possible that disturbances such as forrest clearing, ditching and sand mining break the dormancy of seeds contained in the seed bank, where perhaps, they are relics from a time when more favorable conditions prevailed. In Delaware, a population of *R. aristosa* was recently discovered in a area that had been clear cut, ditched, and planted with *Pinus taeda* seedlings (B. McAvoy pers. comm.). This suggests that the species was present in the seed bank prior to the clearing. A study of aerial photography dating back to the 1930's, indicates that a number of depressional ponds may have existed at this site which were eventually succeeded by woody vegetation (B. McAvoy pers. comm.).

Rhexia aristosa, like all the taxa of *Rhexia* occurring in New Jersey, is a perennial. However, under certain conditions or in certain habitats, the species may be very short-lived or be annual. Reproduction is both sexual and asexual. Asexual reproduction is through underground tubers and the very occasional rhizome. Like those of *Rhexia virginica*, the tubers of *R. aristosa* are likely short-lived. Under adverse environmental conditions (i.e. successive years of exceptionally high or low water levels) it is possible that the entire rootstock may succumb. Like many species adapted to cyclical or dynamic habitats, seed banking is key to long term survival. Seed production in *R. aristosa* is copious with the seeds capable of persisting in the seed bank for an undetermined number of years. Sutter and Boyer (unpublished) found *R. aristosa* to be a prolific seed banker: one soil sample contained 6,872 seeds per square meter. They also found that seeds germinated only when the substrate remained moist or was subjected to simulated drawdown. Seeds grown in permanently saturated or inundated substrates did not germinate.

These data support the inferred conclusions of many observers familiar with the yearly fluctuation of population sizes of *R. aristosa.* My five year observations of the Little Goose Pond population provide a dramatic example. 1989 and 1990 were years of exceptionally high rainfalls in New Jersey. Only a few plants were found in 1989 and none were located in 1990. By July, 1991, with a return of more typical pattern of rainfall, thousands of seedling plants were observed in dry, or nearly dry portions of the pond. In late August of 1992, the pond was almost completely dry, and I estimated 38,000 plants. Most were small, unbranched or with a few branches. Only a small percentage matured sufficiently to produce flowers. In the summer of 1993 much of New Jersey was experiencing near drought conditions. At the height of a record breaking week of temperatures near or above 100 degrees, the mortality rate for *Rhexia aristosa* was high: few seedlings survived and thousands of the mature plants were blackened or wilted. Few flowering plants were observed, but the few that were, were restricted to portions of the pond where standing water remained. Rain showers, although infrequent or brief during much of the summer, became more regular in September and October. Despite the earlier high mortality, more than 50,000 plants were estimated in October, with a high percentage of these being large, flowering plants. Countless seedlings, apparently recently recruited, and young plants were also present.

Flowering is from mid July to late September, occasionally a little earlier, or later, depending on water levels. The foliage turns dark purple-brown, appearing almost black, and frequently tinged with deep red, especially along veins, stems, and hypanthia. The purple-brown pigmentation often begins to show in late July as blotchy, dark spots, the coloration remaining uneven throughout the remainder of the season. When growing in deep water, stem leaves are commonly deciduous, otherwise the leaves persist until frost.

As acknowledged by James (1956) and Kral & Bostick (1969), *Rhexia aristosa* is one of the most distinctive taxa in the genus. In morphological characters, *R. aristosa* is most similar to *R. virginica*, and ordinarily the two are easily differentiated. *Rhexia virginica* is somewhat variable (more so in the southern part of its range than in New Jersey material) and some specimens superficially suggest *R. aristosa*. However, the narrow leaves, leafy inflorescences, coarse trichomes on the rims of the hypanthia, and very long, attenuated sepal lobes tipped with stout, eglandular awns are diagnostic for *R. aristosa*.[4] Fertile hybrids between *R. aristosa* and *R. virginica* have been artificially produced by Kral & Bostick (1969). James (1956) noted that among specimens of *R. aristosa* and *R. virginica* that he examined, were a number of specimens collected from several different localities, that were "distinctly intermediate between the two." I have examined New Jersey material so annotated by James and others, as well as living material, and discuss them below as *Rhexia × brevibracteata*.

REPRESENTATIVE NEW JERSEY SPECIMENS EXAMINED. **Atlantic Co.:** Wet place, Egg Harbor City, 1 Aug 1888, *J. E. Peters s. n.*, (type and isotype) NY[5]; Near Egg Harbor City, 15 September 1896, *G. M. Beringer s. n.*, NY; Egg Harbor City, 17 Aug 1897, *B. Heritage s. n.*, PH; Egg Harbor City, 17 Aug 1898, *C. D. Lippencott s. n.*, PH; Little Goose Pond, 20 Jul 1957, *Bob Hirst s. n.*, PH; Shallow water, Little Goose Pond, 6 Aug 1960, *A. J. Hoiberg 1013*, CHRB; Shallow water, Little Goose Pond, Egg Harbor City, 20 Aug 1979, *D. B. Snyder 599-2RU*, CHRB; Abundant (ca. 38,000 plants) on nearly dry bottom of a large intermittent Coastal Plain pond, Little Goose Pond, Egg Harbor City, 31 Aug 1992, *D. Snyder 599-5*, DBS; Thousands (ca. 50,000) of plants scattered throughout dry, to nearly dry bottomed Coastal Plain intermittent pond, Little Goose Pond, Egg Harbor City, 7 Oct 1993, *D. Snyder 599-7RU*, CHRB, DBS; 1,000 or so plants growing on dry bottom of large intermittent Coastal Plain pond, SW bay of Big Goose Pond, Egg Harbor City, 31 Aug 1992, *D. Snyder 599-15*, DBS; Berlin Ave. and RR, Cologne, 29 Jul 1959, *B. Hirst s. n.*, PH. **Cape May Co.**: Small colony on nearly dry bottom of shallow sand pit, ca. 1 mi W of Petersburg, 18 July 1991, *D. Snyder 599-18*; Small colony on nearly dry bottom of shallow sand pit, ca. 1 mi W of Petersburg, 29 Jul 1991, *G. Cavileer, K. Seager*, and *D. Snyder 599-20* DBS; Small colony on dried bottom of shallow sand pit, ca. 1 mi. W of Petersburg, 10 Sept 1993, *D. Snyder 599-25RU*, CHRB.

5. **Rhexia × brevibracteata** Snyder, hybr. nov.
Rhexia aristosa Britt. × *Rhexia virginica* L.
Hybrida naturalis inter parentes media.

Erect perennial herb to 72 cm from tuberiferous rootstocks, usually without horizontal stoloniferous rhizomes. Rhizomes when produced, slender, short or long creeping, but soft and flexible. Roots and stems frequently spongy thickened when growing in water for prolonged periods of time. Stems four angled, all sides being nearly equal in width, the angles wingless or with narrow wings, internodes nearly glabrous except for a very few spreading, mostly glandular hairs, nodes with conspicuous tufts of coarse hairs, these either glandular or not, few to bushy branched. Leaves predominately lanceolate, occasionally broadly so, sometimes ovate on lateral branches, 2.2-4.3 cm long, 0.5-1.9 cm wide (mostly 1 cm or more), sessile, apex obtuse to acute and mostly mucronately tipped, adaxial surfaces sparsely hirsute to nearly glabrous, abaxial side prominently tripled-nerved, the nerves yellowish, often with an additional pair of less conspicuous nerves along the margins, secondary nerves none to present, faint and not well developed when present, the surface glabrous except for a few appressed coarse hairs along the nerves, margins serrulate, the teeth mostly divergent and aristate-tipped. Leaves reduced (commonly abruptly) in the inflorescence, the uppermost becoming scale-like and many times shorter than the hypanthia. Inflorescence an open or contracted cyme, few to many flowered. Flowers deep rose to magenta, up to 3 cm across, petals broadly obovate, asymmetrical, tipped with a mostly glandular hair, abaxial surfaces with numerous glandular hairs. Hypanthia at maturity 5-11 mm long, with necks slightly shorter to barely equalling the bodies, sparsely glandular-hairy throughout, the rims with more numerous and coarser hairs up to ca. 2 mm long, calyx lobes lanceolate to triangular-lanceolate, 2.1-3.1 (4.5) mm long, tipped with a slender hair ca. 1 mm long and mostly gland-tipped. Seeds cochleate, 0.5-0.7 mm long, surface irregularly, but concentrically ridged, the ridges relatively high and comprised of contiguous to isolated muricate processes varying to more regularly ridged with papillose processes.

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[4] The trichomes on the hypanthia and sepal lobes of both *R. aristosa* and *R. virginica* become brittle upon drying and are often broken or missing on specimens. This is also true for specimens collected very late in the season which have weathered or dehiscent fruit capsules. The nature of the trichomes, especially the presence or absence of glands, is best observed on living specimens or on dried specimens having buds, flowers, and reasonably mature capsules.

[5] Although these specimens were collected by E. H. Kilmer and J. C. Gifford (Britton 1890), only J. E. Peters' name appears on the preprinted label.

Specimens of this presumed hybrid were first collected from New Jersey by K. K. Mackenzie on 10 August 1913 near Egg Harbor City, Atlantic County (*5584* CHRB, GH, NY, PH). Annotations on his specimens, and notes entered in his collecting journal (unpublished), suggest that Mackenzie struggled with the identification of these specimens. On some specimens "*Rhexia*" is written in ink, followed by "*aristosa*" in pencil; others are followed by "*virginica*" which was then crossed out and replaced with "*aristosa*." Still other specimens are identified only as "*Rhexia*." In his journal, specimens of *5584* are entered as "*Rhexia aristosa* Britt.," but followed by the comment, "*5584* may be only a form of *R. virginica* produced under artificial conditions." On one of the labels of his specimens (NY) he wrote, "This *species* [my emphasis] is merely a form of *R. virginica*." Mackenzie apparently never saw genuine *R. aristosa* in the field; if he did, he never collected specimens. Based on his *5584* series, and the few specimens of *R. aristosa* available to taxonomists early this century, it is understandable why Mackenzie would question the taxonomic validity of *R. aristosa*.

Mackenzie was not alone in having difficulty in identifying these specimens. F. W. Pennell in 1918 annotated one of the Mackenzie series (NY; named as *R. aristosa* by Mackenzie) as *R. virginica*. This specimen, as well as two others of the series (also NY) were then annotated to "?*Rhexia aristosa* × *R. virginica*" by James in 1955. In 1986, R. Bounds annotated one of the specimens to *R. aristosa* (the one annotated to *R. virginica* by Pennell) and two as *R. virginica*. In unpublished notes, Bounds (pers. comm.) says about the specimen he annotated as *R. aristosa*, "I somewhat agree [with James' annotation of ?*Rhexia aristosa* × *R. virginica*] but would say perhaps some *virginica* genes have introgressed into this." Current opinions are also at odds. Frank Hirst (pers. comm.), who, with his brother Robert, rediscovered Mackenzie's locality in the late 1950s, considered these plants to be possibly hybrids of *R. aristosa* and *R. virginica*. A. E. Schuyler collected and labeled a specimen as *R. virginica* (23 Jul 1980, 5456, PH). Specimens from this locality (DBS; VDB), plus identical material that I collected from two other nearby localities, were identified by Robert Kral as *R. aristosa*, although he commented (pers. comm.) that these were, "tough calls indeed." Over the last 14 years that I have been studying this material, I have variously identified these specimens as *R. aristosa*, *R. virginica*, or hybrids between these taxa.

James (1956) stated that *R. aristosa* and *R. virginica* are "typically quite distinct morphologically." According to Kral & Bostick (1969), *R. aristosa* is "one of the most distinctive in the genus." Further, specimens of *R. aristosa* collected throughout its range are consistently similar and show little significant morphological variation. This being so, then why has there been such a divergence of opinions on the proper disposition of Mackenzie's *5584* and subsequent collections of this material? Slight discrepancies in the keys of some manuals may have contributed somewhat to the uncertainty, but the primary obstacle has been the lack of sufficient material to study (sheets of Mackenzie's *5584* are few, scattered between herbaria, and due to the usual wear and tear that specimens are subjected to, are often deficient in critical characters). With the relocation of the two populations known to Mackenzie, and the discovery of two additional populations, a critical evaluation is now possible.

In general appearance, the hybrid plants are more suggestive of *R. virginica.* The leaves are on average wider, and more broadly lanceolate then is typical for *R. aristosa*, and the leaves of the inflorescence are conspicuously reduced, unlike the leafy bracted inflorescence of *R. aristosa.* On closer examination, the rims of the hypanthia have coarse yellowish trichomes (strictly a characteristic of *R. aristosa*) and the sepal lobes are longer than those of typical *R. virginica.*[6] However, the trichomes, on average, are shorter and less coarse than those of *R. aristosa*, and many are gland-tipped (more characteristic of *R. virginica*). The sepal lobe is not tipped with a stout, eglandular awn, as is *R. aristosa*, but is tipped with a fairly slender, usually glandular hair as is usually *R. virginica.* The seeds of *R. × brevibracteata* are ridged with processes that are distinctly muricate or papillose (although a few smoother ridges may also be present), giving the surface a decidedly rough or granular appearance, especially at lower magnifications, in contrast to the smoother, more wrinkled look of seeds of *R. aristosa.* Based on the length and shape of the sepal lobes and the presence of coarse trichomes on the hypanthium, *R. × brevibracteata* appears more closely related to *R. aristosa* then to *R. virginica*, and if it were not for the greatly reduced bracteal leaves of the inflorescence, it would be difficult to distinguish it from robust plants of *R. aristosa.*

Rhexia × brevibracteata has been documented only from Atlantic County, New Jersey. Four extant populations are currently known from three separate sites located between Egg Harbor City and Port Republic. The greatest distance between sites is 3.7 miles. All sites are located very near documented occurrences of *R. aristosa.* No site is farther than 3.7 miles from a historical occurrence of *R. aristosa* or 8.4 miles from an extant occurrence. Although natural occurring hybrids between *R. aristosa* and *R. virginica* have been reported in the southern range of *R. aristosa* (R. Kral pers. comm.), there is no evidence that these hybrids are morphologically coherent, persistent, stable, or taxonomically significant. Clearly more study is needed.

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[6] The *purshii* phase of *R. virginica* has sepal lobes which in size (up to 4 mm) and shape (lanceolate) approach those of *R. aristosa* or *R. × brevibracteata* . However, *purshii* material lacks the coarse hypanthial trichomes (hypanthia often completely glabrous) of these taxa and the surficial sculpturing of its seeds are more like those of typical *R. virginica.*

All known occurrences for *R.* × *brevibracteata* are in inactive sand pits, similar to those described under *R. aristosa*. Two pits (Egg Harbor City) are shallow, water-filled excavations, which are normally dry by mid summer and are well vegetated with a diversity of wetland sedges, grasses, and herbs. Characteristic species include *Eleocharis microcarpa*, *Rhynchospora knieskernii*, *Scirpus cyperinus*, *Muhlenbergia torreyana*, *Panicum verrucosum*, *P. virgatum*, *Xyris difformis*, *Ludwigia linearis*, *Gratiola aurea*, and *Eupatorium luecolepis*. The other two sites (South Egg Harbor, Port Republic) are much deeper excavations and have areas in which water levels regularly drawdown or dry out completely, but are also interspersed with much deeper pond-like excavations that usually hold water throughout the year. Most of the above listed taxa are present with *Xyris smalliana*, *Ilex glabra*, *Vaccinium macrocarpa*, and *Coreopsis rosea* as notable additions. In these latter sites, *R.* X *brevibracteata* grows in areas of fluctuating water levels in shallow depressions and "pond" margins and bottoms and also in higher topographic positions characterized by nearly barren, and comparatively dry sand—a habitat decidedly drier than that of *R. aristosa* or *R. virginica*. Populations range in size from several hundred to several thousand plants. There is little variation within and between populations, except in stature, branching, and leaf dimensions, which is perhaps more a result of age and fluctuation of water levels. *Rhexia virginica* is present at all documented sites, ranging in abundance from rare to infrequent. Only at one site (near Port Republic) were plants collected that could not be definitely referred to *R. aristosa*, *virginica*, or × *brevibracteata*. These plants were few, and grew mixed with typical specimens of *R.* × *brevibracteata* and *R. virginica*. Historically, *R. aristosa* was documented at one *R.* × *brevibracteata* site (Cologne, 29 Jul 1959, *B. Hirst s. n.*, PH) but despite repeated searches, it has not been found there since, or has it been discovered at any of the other *R.* × *brevibracteata* sites.

Flowering normally occurs from mid July through late September, but varies somewhat, depending on seasonal water levels. Fall coloration of the leaves is similar to *R. aristosa* with leaves turning a blotchy purple-brown in early summer, the pigmentation becoming darker and red tinged later in the season. Leaves persist until frost.

Although artificial hybrids between *R. aristosa* and *R. virginica* have been produced experimentally (Kral & Bostick 1969), naturally occurring hybrids between these taxa are apparently quite rare (R. Kral pers. comm.). Given the rarity of *R. aristosa* and the usually different habitats occupied by each species (intermittent ponds vs. herbaceous wetlands), this is not surprising. Field observations suggest that *R.* × *brevibracteata* is a fertile hybrid. Seed production is copious, with a high percentage of full seeds produced. Numerous seedlings have been observed at all the known localities. Cyclical fluctuations of population sizes similar to those reported for *R. aristosa* have also been observed at one locality. The populations declined during successive years of high water levels and recovered in years of average or lower than average water levels, with recruitment apparently through the seed bank. Further, viable seeds provide a more likely explanation as to how *R.* X *brevibracteata* has been dispersed to other sand pits which are separated from each other by a few miles as well as a myriad of roads, agricultural lands, small towns, and other barriers to dispersal. Such barriers are easily crossed by waterfowl. Each population could have arisen independently as a result of chance hybridization, but given the rarity of *R. aristosa* in New Jersey and the distance between documented sites of it and the hybrid, it seems the least likely explanation.

Rhexia × *brevibracteata* likely arose as the result of the chance hybridization of *R. aristosa* and *R. virginica*, and through subsequent backcrossing, possibly with *R. aristosa*, it has become a stable, morphologically distinct, and apparently sexually reproducing taxon. Evidence supporting this conclusion is sumarized as follows: (1) fertile hybrids between the putative parents have been produced experimentally; (2) both putative parents are morphologically distinct, each possessing unique morphological characters which do not overlap; (3) the putative hybrid posseses no unique morphological characters, but combines characters from each of the supposed parents in an unique assemblage; (4) the hybrid is documented from only a very small geographical area where both putative parents occur together; (5) all documented occurrences of the hybrid occur in artificially created habitat. It is clear that *R.* × *brevibracteata* can not be taxonomically accommodated as a phase of *R. aristosa* or *R. virginica*, to do so, would blur the morphological distinctions of the latter two sharply defined taxa.

TYPE: NEW JERSEY: **Atlantic Co.:** W side of the Garden State Parkway, between Indian Cabin Road and Clarks Mill Stream, ca. 1.2 mi W of jct of Mill Street and Main Street, Port Republic. Thousands of plants scattered throughout a complex of inactive sand pits. Plants growing in shallow water along edge of pond-like excavations, 16 Sept 1993, *D. Snyder*, PH (**ISOTYPES**: CHRB, DBS, NY).

ADDITIONAL NEW JERSEY SPECIMENS EXAMINED: **Atlantic Co.:** W side of the Garden State Parkway, between Indian Cabin Road and Clarks Mill Stream, ca. 1.2 mi W of jct of Mill Street and Main Street, Port Republic. Thousands of plants scattered throughout a complex of inactive sand pits. Growing in wet sand of shallow excavations. Scattered plants of *R. virginica* present but no *R. aristosa* present, 17 Aug 1992, *D. Snyder*, DBS, PH, VDB; Shallow artificial pond, Egg Harbor City, 10 Aug 1913, *K. K. Mackenzie 5584*, CHRB, GH, PH, NY; 1.4 mi SE of Egg Harbor City, W side Berlin Ave, S side of RR. Scattered on now dry, sandy bottom of inactive borrow pit, 21 Aug 1980, *G. Cavileer, F. Hirst,* and *D. Snyder*, DBS; 2.2 km SE of Egg Harbor City, SW side of small pond west of Berlin Ave and RR. Scattered plants in moist sand, 23 Jul 1980 *A. E. Schuyler 5456*, PH; 1.4 mi SE of Egg Harbor City, W side Berlin Ave, S side of RR. Abundant in shallow water and in wet sand on nearly dry bottom of inactive borrow pit, 7 Oct 1993, *D. Snyder*, CHRB, DBS, NY, PH; Berlin Ave and RR, Cologne, 29 Jul 1959, *B. Hirst s. n.* (mounted with a specimen of *R. aristosa*), PH; 1.4 mi SE of Egg Harbor City, E side Berlin Ave, N side of RR. Abundant (3,000+) on nearly dry, sandy bottom of an inactive borrow pit, 25 Sept 1991, *D. Snyder*, DBS, PH, VDB; 1.4 mi SE of Egg Harbor City, E side Berlin Ave, N side of RR. Scattered throughout mostly dry bottom of inactive borrow pit, 7 Oct 1993, *D. Snyder*, DBS; Sand pits on S side of Belladonna Ave., South Egg Harbor. Ca. 1,700 plants, mostly growing in drier portions of inactive sand pits, some growing in seemingly dry sand, 5 Aug 1992, *D. Snyder*, CHRB, DBS, NY, PH, VDB; Sand pits on S side of Belladonna Ave., South Egg Harbor. Scattered plants growing in moist to dryish sand on the bottom of a series of inactive sand pits, 7 Oct 1993, *D. Snyder*, DBS.

ACKNOWLEDGMENTS

I thank curators at CHRB, GH, NY, PH and Gerry Moore for making specimens available. Richard Bounds, Frank Hirst, Bill McAvoy, Ernie Schuyler, Rob Sutter, and Alan Weakley helped with various aspects of this paper. Larry Morse reviewed an early draft. My special thanks to Robert Kral for reviewing the final manuscript, annotating specimens, and his many insightful comments and discussions on the *Rhexia* taxa of New Jersey.

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The Botanical Work of the Ruth Brothers of Bucks County, Pennsylvania, and its Significance Today

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In December 1881 22-year-old John Ruth and his 16-year-old brother Harvey decided to "commence the study of botany." They sent away for a copy of "Gray's Manual and Lessons in Botany" (Gray 1867) for $2.16 and began to "get some knowledge of the rudiments of the science." At the first sign of spring they set forth to tramp the woods and fields in the vicinity of their home in the village of Monroe with the stated intent of preparing a "Catalogue of the Flora of Durham." Seven years of intense joint collecting ended in 1889 when John Ruth moved to Bethlehem to take a job with the Lehigh Valley Railroad. In succeeding years John added specimens to their joint herbarium from the vicinity of West Bethlehem, where he lived until September 1913, and later from Clifton, NJ. Harvey, who moved to Pequest, NJ in 1902, continued to add to the collection until his death in 1904.

John A. Ruth (1859-1918) and Harvey F. Ruth (1866-1904) were the sons of a German Lutheran farm family of northeastern Bucks County. Their father, Charles Ruth, later gave up farming and went to work as a blacksmith at the Durham Iron Works. John and Harvey attended public school in Durham Township. At the age of seventeen John was sent to the West Chester Normal School for six months after which he taught school from 1877 to 1888. Following the completion of his formal education in the local public schools, Harvey was employed in the chemical laboratory of the Durham Iron Works.

The observations and collections of this pair of amateur botanists were recorded in detail by John Ruth in seven volumes of botanical notes totalling more than 750 pages and nearly 300 pages of correspondence now preserved in the archives of the Academy of Natural Sciences of Philadelphia (Ruth 1881-1917). The notebooks, written in a neat hand and an almost poetical prose, contain only botanical observations. Few, if any, clues to other events in their lives were included. However, a 44 page typewritten autobiography by John Ruth (Ruth 1897) and a biographical sketch of John Ruth (Fackenthal 1926) provided additional background. In addition, John and Harvey each contributed papers to the Buckwampum Literary and Historical Society of which they were founding members. Titles by John A. Ruth included "The Flora of Buckwampum" (Ruth 1888) read at a meeting held June 14, 1888 and "Our Local Flora" (Ruth 1889) read June 8, 1889. Harvey read a paper on the history of the village of Monroe (formerly Lehenburg) on June 13, 1896 (Ruth 1896). In addition to the botanical notes, the brothers left a "Catalogue of the Flora of Durham and Nockamixon" (Ruth 1887) containing a chronological record of 676 herbarium specimens collected from April 1882 to September 1885, and a 109 page unpublished "Flora of Northeastern Bucks County" (Ruth 1907).

The notebooks also included clippings from the local newspapers (mainly the *Doylestown Intelligencer*) which dealt with topics of a botanical nature such as notices of visits to Bucks County by noted botanists, new botanical finds and obituaries of Asa Gray, Thomas C. Porter and other prominent botanists. "The Ferns of Durham and Vicinity" (Moffat 1889), a paper presented to the Bucks County Historical Society by Miss Margaret Moffat, and also carried in the newspaper, provides a clue to the source of the brothers' early botanical interests. Miss Moffat was Harvey Ruth's teacher at the Monroe School.

John Ruth's notes recorded the brothers' initial efforts at specimen preparation and the improved methods they eventually adopted. John spent many winter evenings working on the collection which he treasured until his death. The Ruth brothers' herbarium, which eventually consisted of 4000 specimens, became the property of a cousin, Benjamin F. Fackenthal, Jr., after John Ruth's death in 1918. Mr. Fackenthal "loaned" the collection to the Academy of Natural Sciences where it remains (Fackenthal 1926; Stone 1920). Users of the local herbarium at the Academy of Natural Sciences of Philadelphia will be familiar with the Ruth brothers' label, purchased from an Easton firm in 1884, with J. A. and H. F. Ruth printed boldly across the bottom.

Like many other amateur botanists of the 1800s, John and Harvey Ruth reflected a strong Victorian era interest in natural history. Before they turned to botany they had amassed a collection of some 400 specimens of minerals and fossils and 3500 Indian artifacts carefully excavated at the site of a prehistoric village along the Delaware River near Kintnersville, all of which are now in the collections of the Mercer Museum in Doylestown (Ruth & Ruth 1878). Both were also very interested in local history and genealogy and made contributions in this area also.

When John and Harvey Ruth made the decision to apply themselves to botany it was a total effort. Starting with "Gray's Manual" mentioned above, they soon built up an extensive botanical library. Green's "Botany", "Trees, Plants and Flowers" (Baily 1870), "Familiar Lectures on Botany" (Phelps 1852), "An Introduction to the Study of Botany" (Comstock 1832), and "Class-book of Botany" (Wood 1881) were purchased in 1883. The following year they added "Grasses of the United States" (Vasey 1883), "Grasses and Forage Plants" (Flint 1858), Carpenter's "Vegetable Physiology and Botany", Cook's "Manual of Botanic Terms", "The Sylva Americana" (Browne 1832), "Catalogue of North American Carices" (Bailey 1884), "The Botanical Collector's Handbook" (Bailey 1881), "Manual of the Mosses of North America" (Lesquereux and James 1884), and "The Naturalist's Directory" (Anonymous 1865-66). In 1885 more books were purchased including "Synoptical Flora of North America" (Gray 1878, 1884), "Catalogue of the Plants Growing Without Cultivation in the State of New Jersey" (Willis 1874) and "Our Native Ferns and Their Allies" (Underwood 1881). In addition the notebooks contain frequent references to such periodicals as: *American Naturalist*, *Torrey Botanical Bulletin*, *Botanical Gazette* and *Proceedings of the American Academy of Arts and Sciences.*

Their equipment included a dissecting microscope made by Harvey from a pocket magnifier purchased for $1.50 and homemade plant presses. In 1883 they purchased a Universal Household Microscope (70 to 290 diameters) for $12.00, with which to examine mosses and other small specimens.

CONTACTS WITH THE BOTANICAL COMMUNITY

By 1883 John was in regular contact with Dr. Isaac S. Moyer, of Quakertown, author of the "Catalogue of the Flora of Bucks County" (Thomas and Moyer 1876; Moyer 1884) and Dr. C. D. Fretz of Sellersville, Dr. Moyer's colleague and successor. The Ruth brothers sent specimens to Moyer and Fretz for confirmation and were proud to add, by John's calculations, over 30 species to the Bucks County list. Fretz' revised catalogue credited J. A. and H. F. Ruth with 26 taxa (Fretz 1905).

One of their first new county records was Harvey's discovery of *Ophioglossum vulgatum* on August 2, 1883. They immediately sent a specimen to Dr. Moyer and received the following letter by return mail:

> Quakertown 8-4-83
>
> My dear sir: Your brother has made a very fine discovery. Dr. C. D. Fretz and myself have been scouring the upper and middle of the county and I. C. Martindale the lower for years, for *Ophioglossum*, and without success. Be kind enough to secure me a few good specimens, root and whole plant. Many thanks for your kindness. It has given me much pleasure. I. S. Moyer

John's comment, penned following the transcription of the letter in his notebook, was: "This pays us richly for what we have spent on botany. It has been our good fortune to add three new species to the Flora of Bucks Co."

The discovery of *Ophioglossum* was followed quickly by Harvey's collection of *Gentianella quinquefolia* (formerly *Gentiana quinquefolia*) on October 3, 1883. Upon receiving a specimen, Moyer had the following comment: "Your plant is *Gentiana quinquefolia* sure enough, and is an excellent find . . . thanks to your researches-we can add it to the flora of good old Bucks." A letter soon arrived from Fretz congratulating the brothers on their finds, requesting specimens of both and promising to send "specimens of mine" in return.

John and Harvey also corresponded with Thomas C. Porter, of Lafayette College in Easton whose "Flora of Pennsylvania" (Porter 1903) was published posthumously. From 1885 through 1889 the Ruth brothers exchanged specimens with Porter and through their collecting efforts, contributed several new state records including: *Panicum boscii* (formerly *Panicum latifolium* var. *molle*), *Scirpus cyperinus* (formerly *Scirpus eriophorum* var. *cyperinus*) and *Scirpus sylvaticus*. John later discovered *Anthoxanthum aristatum* (formerly *Anthoxanthum puelii)*, a European grass not previously collected in the state, growing in his lawn in West Bethlehem. Porter repeatedly urged the brothers to, "pay me a visit and take a look at my herbarium and botanical library and appliances." However, there is no evidence that they ever did.

Other professional botanists with whom the Ruth brothers were in occasional contact included L. H. Bailey, then of the Michigan Agricultural College, whom they consulted regarding several *Carex* species; George Vasey, agrostologist at the Smithsonian Institution in Washington, DC who identified several grasses for them, and Dr. N. L. Britton, of the Columbia College Herbarium and later the New York Botanical Garden. They also sent specimens to A. S. Hitchcock, of the State University of Iowa and later the Smithsonian, and Dr. H. H. Rusby of Columbia College.

By 1885 John and Harvey were actively involved in exchanging herbarium specimens with other amateur botanists whom they located through the "Naturalists Directory". Correspondence and lists of specimens offered, as well as "dissiderata" were included in the correspondence (Ruth & Ruth 1882-1918). There were frequent references in the notebooks to collecting specimens for exchange. Exchanges were recorded with other local PA and NJ botanists as well as correspondents in NY, MT, ME, IL, CA, NE, FL, and MA.

Although their herbarium and notes were eventually deposited in the Academy of Natural Sciences of Philadelphia, there is little evidence that John and Harvey had much contact with that institution during their lives. John Ruth sent a specimen of *Rumex* to the Academy in 1912 which Stewardson Brown identified as *R. crispus* L. (Anonymous 1912). John wasn't satisfied with that determination and subsequently sent specimens to the National Arboretum and the New York Botanical Garden where botanists identified the plant as *Rumex triangulivalvis* (formerly *R. mexicanus).*

The Philadelphia Botanical Club was not founded until 1891, after John had left Bucks County to live in West Bethlehem. An 1896 card from Dr. C. D. Fretz to Harvey contained an invitation to join a field trip to the Nockamixon Rocks by the Philadelphia Botanical Club and the Torrey Botanical Club. Whether Harvey did so is not known.

COLLECTING SITES

John and Harvey Ruth botanized the northeastern corner of Bucks County. With few exceptions, their activity was limited to the area they could reach on foot from their home in the village of Monroe located along the Delaware River two miles south of Riegelsville. Quite by chance this corner of the county has a highly varied geology which contributes to the diversity of plants found in the region. The Monroe Border Fault, which intersects the Delaware River near the village of Monroe, forms an abrupt boundary between the Triassic shale, sandstone, quartzite and diabase to the south and a band of Cambrian limestone and Precambrian gneiss, which are part of the Reading Prong, to the north (Geyer & Bolles 1987). In addition a fairly extensive deposit of Quaternary sand and gravel occurs along the river in the vicinity of Kintnersville (Greenman 1955).

Collecting sites visited frequently by the Ruths included the Nockamixon Cliffs, Wykers (formerly Lynn) Island, Buckwampum Mountain, Cooper and Hewitt's pond, woods near Durham Church, and the Nockamixon swamps. Although the intensity of collection and degree of description of these sites varies, the information in the notebooks and manuscript floras allowed us to make some comparisons between the appearance and species makeup of these sites in the 1880s and their condition today. Of particular interest are early collections of species now classified as endangered (PE), threatened (PT), rare (PR), vulnerable or undetermined (TU) in Pennsylvania (Commonwealth of Pennsylvania 1993). Overall, the Ruth collections included 17 taxa of concern to the Pennsylvania Natural Diversity Inventory.

NOCKAMIXON CLIFFS. The most famous of the sites frequented by the Ruths was the sheer, northwest facing cliff along the Delaware River between Kintnersville and Narrowsville. Several streams cascade down the 300 foot cliff face forming cool, moist ravines which harbor such rarities as the arctic-alpine species, *Sedum rosea* (PE). Even before T. C. Porter's discovery of *Sedum rosea* at the site in 1867, the Nockamixon Cliffs drew the attention of botanists. C. S. Rafinesque called the cliffs "the greatest natural curiosity on the Delaware River . . . I found here the *Adlumia* and many other rare plants." (see Benner 1935). Other notable local botanists who have examined the flora at the site have included John Harshberger; A. P. Garber (a student of Porter's), S. S. Van Pelt, J. W. Eckfelt, Thomas Seal, C. S. Williamson, Harold Pretz and Walter Benner (Harshberger 1899, 1909). Specimens of *Sedum rosea* collected by all of them can be found today in the Academy of Natural Sciences Herbarium.

Aster ericoides (TU), collected at a rocky promontory at the top of the cliff known as

"Top Rock" by John and Harvey, was found at the exact same spot in September 1991. However several other species, including *Taxus canadensis* (TU), described by the Ruths as abundant on the cliffs along the river from Monroe south, are apparently gone. Over browsing by Virginia white-tailed deer may well be the cause, *Taxus* is preferred winter browse (Allison 1990) and deer trails, pellets and browse lines are abundant on upper slopes above the cliffs.

A 28 acre section of the Nockamixon Cliffs was recently added to the adjacent Delaware Canal State Park through the efforts of the Heritage Conservancy's Significant Natural Areas Protection Program.

WYKERS ISLAND. Formerly known as Lynn Island, Wykers Island is located in the Delaware River opposite the Nockamixon Cliffs near the town of Kintnersville. The island, which is covered with a dense floodplain forest, is approximately 14 acres in area. As is typical of river islands, the upstream end is characterized by alluvial sand and cobble deposits with dwarfed and distorted tree and shrub growth which is frequently scoured by flooding. The downstream end of the island is higher, less frequently flooded and supports mature forest. Although John Ruth referred to an earlier time when part of the island was farmed, it does not appear that there has been any disturbance in the past 100 years other than that caused by the river itself. One *Liriodendron tulipifera* with a four foot trunk diameter and a number of trees exceeding three feet dbh were observed in 1992.

In six visits to the island between August 1884 and October 1887 the Ruths compiled a list of 197 species. In May and August visits in 1992, we noted a total of 151 taxa, approximately 55 of which appeared on the Ruth brothers' list. 1992 data included 40 species of trees and shrubs of which one of the most interesting was *Diospyros virginiana*, the native persimmon, which formed a grove near the upper end of the island. John and Harvey noted "a small tree well in fruit" 100 years earlier.

The island proved to be fertile ground for new county records to add to John and Harvey's list. *Eragrostis capillaris*, *Spartina pectinata* (formerly *S. cynosuroides*) and *Lythrum salicaria* were first collected on September 9, 1884 and *Cyperus dentatus* was added in 1885. A specimen of *Lythrum salicaria*, "a single plant along the eastern shore near the water's edge," was sent to Moyer for confirmation, and pronounced by him as "very rare" and "a splendid find". However the species was not seen the following year leading John to conclude that it had "probably been destroyed." By a hundred years later *Lythrum salicaria* had spread up and down the river and become a major threat to native wetland species throughout the northeastern states (Thompson et al. 1987).

Prunus pumila and *Lupinus perennis* (both PR), were collected by the Ruths on the island. On May 20, 1887 John recorded the following notes regarding these species: "One of the first plants found was *Prunus pumila* in flower. It is spread over the stony northern end . . . . Near by we found large beds of lupine in flower . . . ." Recent searches indicated that these species were not present on the island, presumably because there was less open area at the upstream end. Other differences between John and Harvey's species list and our 1992 data support the conclusion that formerly open areas on the island's northern end have grown up in the past 100 years perhaps due to less frequent scouring by ice. The Ruths listed 65 species in the families Poaceae and Asteraceae, in contrast to the 22 species which we observed in 1992. *Prunus pumila* is still abundant on islands further upstream where the habitat is more open.

Another state rarity, *Gratiola aurea* (TU), collected by John and Harvey in mud at the north end of the island, could not be relocated in 1992. It has not been found recently at other former locations along the river in Bucks County either.

Tradescantia ohiensis (TU) was abundant throughout the island's interior in May 1992. While John and Harvey did not list this species, they did record the presence of *T. virginiana.* Gray did not recognize *T. ohiensis* (Gray 1867, 1887) in the manuals the Ruths had access to, and described *T. virginica* as highly variable, smooth or hairy. Since the two species are distinguished mainly by the pubescent sepals and pilose pedicels of *T. virginiana* vs. glabrous sepals and pedicels of *T. ohiensis* (Fernald 1950), it is possible that the species we saw in 1992 was the same thing that was present 100 years earlier. Unfortunately there was no Ruth herbarium specimen of *Tradescantia* from the island so it was impossible to be certain what they saw. Interestingly, a Ruth specimen labelled as *T. virginiana* collected from the riverbank at Monroe was correctly identified by today's definition of that species. *T. virginiana* had also been collected at other nearby sites.

A further complication was the fact that *T. ohiensis* is frequently cultivated and may have been introduced to the island via flood waters as have many other species. The process, described by John Ruth in the following excerpt, "seeds from distant localities . . . brought by the freshets and deposited among the drift heaps where in time they spring up and become established," has continued over the years. Today the herbaceous flora of much of the island's interior is dominated by exotics such as *Alliaria petiolata, Anthriscus sylvestris, Hesperis matronalis, Microstegium vimineum, Lonicera japonica, Lamium purpureum, Glechoma hederacea, Allium vineale* and *Polygonum cuspidatum*, none of which were reported 100 years ago.

BUCKWAMPUM MOUNTAIN. Located between Durham Road and Route 412 in Springfield Township, Buckwampum Mountain was the childhood home of John and Harvey Ruth and later a favorite collecting site. John Ruth's notes record 21 visits to the site between 1882 and 1887. It was there in a "large open bog on the east side of the hill" that they collected *Drosera rotundifolia* in 1884. Another local rarity *Platanthera psycodes* (formerly *Habenaria psycodes*), was found in abundance along streams southwest of the "bog" in 1886. Neither of these species was found during repeated searches of the eastern slopes of the mountain in recent years. Although much of the area remained forested, and appeared intact, the canopy at the "bog" was fairly dense and the area was apparently much shadier than it was at the time of the Ruths' visits. Abundant deer trails and a generally sparse shrub layer indicated that browsing by deer may also have been a factor in altering the species composition. *Hydrastis canadensis*, listed as vulnerable on the state list, and not mentioned at all by the Ruths, formed an extensive stand on the mountain in 1992.

COOPER AND HEWITT'S POND. This vernal pond located just south of Rattlesnake Hill, was one of two sites at which the Ruths collected *Gentiana flavida* (formerly *G. alba*) (TU). John and Harvey were very intrigued with this find and corresponded with Thomas C. Porter about it. At the time, Porter struggled with the occurrence of this gentian in eastern PA and hypothesized that it was transported from the southwest part of the state by Indians. Subsequent collections from Lehigh and Northampton Counties have confirmed that the range of this species included eastern PA. John Ruth described the pond as "surrounded by a growth of oak, maple, dogwood and other trees . . . dry at all seasons except the spring." In 1992 the only evidence of its former location was a slight indentation in an expanse of cultivated fields, an indication of the fragility of this habitat type.

WOODS NEAR DURHAM CHURCH. These woods, which occur on the southern slope of the Reading Prong on Precambrian gneiss, were visited several times by the Ruths, and were the subject of John's reverent admiration. Local knowledge of the botanical curiosities of this wooded ravine no doubt inspired him when in 1884 he wrote the following in his notebook:

> A stream of purest spring water, with its several branches, winds in and out among the majestic trees . . . . Gray, mossy, gnarled old oaks that have weathered the storms of a century skirt the banks of the little stream. Tulip poplars, straight as an arrow, rise to the height of a hundred feet. Fine maples, beech, and chestnuts add their foliage. A feeling of awe comes over me when in such a grove. No temple reared by human hands is more imposing.

Although John and Harvey reported such local rarities as *Obolaria virginica*, *Galearis spectabilis* (formerly *Orchis spectabilis*), *Liparis liliifolia*, and *Asclepias exaltata*, none of these were located in a May 1992 visit. Non-native species such as *Rosa multiflora* and *Lonicera japonica* had invaded the peripheral areas, but the central portion of this stream valley remained an intact native woodland. The forest of *Fraxinus americana* and *Liriodendron tulipifera* appeared to be the result of at least partial cutting 50 or 60 years ago. Steep slopes contained a more mature beech-oak forest. Scattered along the stream were many seepage areas with moss covered rocks and dense stands of *Symplocarpus foetidus*. Early reports indicated that *Trollius laxus* (PE) once grew in one of these boggy ravines (Thomas & Moyer 1876). Although it was mentioned in a newspaper clipping preserved in John's notes, there was no evidence that the Ruth brothers ever came across this species in their botanizing.

NOCKAMIXON SWAMPS. The Nockamixon Cliffs were formed by partly metamorphosed shale and siltstone hardened by the heating effect of a massive igneous intrusion (Greenman 1955). The diabase sill which resulted forms a poorly drained, rocky upland above the cliffs of which Coffman Hill is the high point. Much of the area, which is characterized by sluggish, boulder-strewn streams, wet meadows and moist, rocky woods, is presently included in State Game Lands Number 56. The remainder is abandoned farms and low density rural lots with numerous small, manmade ponds.

John Ruth found the meadows and swamps of this region most interesting. On June 1, 1886 he described them as, "a mass of flowers . . . one of the most beautiful sights you ever beheld . . . large patches golden yellow with the flowers of *Krigia biflora* (formerly *Cynthia virginica*) and *Senecio aureus* . . . acres blue with *Iris versicolor*. . . and here and there small patches of scarlet which announce the presence of *Castilleja coccinea* . . . ditches are filled with . . . *Orontium aquaticum* . . ." Other rarities found in the area included *Carex buxbaumii*, *Carex tetanica* and *Eriophorum gracile*.

While meadows tend to be early successional habitats, and thus not stable, long-term plant communities, areas such as those described by John Ruth can still be found in the diabase region of Bucks County. Repeated searches in recent years have failed to locate extant populations of *Orontium aquaticum* (PR) or *Eriophorum gracile* (PE); but other species such as *Carex buxbaumii* (TU), *Carex meadii* (TU), *Castilleja coccinea* (TU) and *Phlox pilosa* (TU) were still present. In addition species such as *Caltha palustris*, *Carex squarrosa*, *Phlox maculata*, *Lilium canadense*, *Platanthera lacera*, *Scirpus pendulus*, *Liatris spicata*, *Andropogon gerardii*, *Sorghastrum nutans*, *Helianthus giganteus*, *Rudbeckia triloba*, *R. fulgida*, *Cirsium muticum*, *Eupatorium fistulosum*, *Gentiana andrewsii*, and *Gentianopsis crinita* continue to make these wet meadows a botanical delight as well as a succession of color throughout the season.

CONCLUSION

Change has come to a number of the collecting sites John and Harvey Ruth frequented 100 years ago. The most severe is altered land use which has totally eliminated a vernal pond and continues to threaten other areas such as the Nockamixon swamps and the lower slopes of Buckwampum Hill. The least disturbed sites are Wykers Island and the Nockamixon Cliffs, which are protected in part by their difficult access. However, even those sites have lost some of their earlier diversity. Changes in the flora of Wykers Island appear to be related to reduced scouring by ice and the constant introduction of exotic species via flood waters. Succession and over browsing by Virginia white-tailed deer are apparently factors in the loss of species from several sites.

In many ways John and Harvey Ruth fit the description of amateur botanists of the nineteenth century developed by Keeney (1992). By collecting intensively in a local area they were able to provide a welcome extension of the work of the professionals, who were in turn willing to assist the brothers with difficult identifications, exchange specimens with them, and offer encouragement. They also became active participants in a nationwide network of amateur and professional botanists involved in the exchange of botanical specimens.

However, unlike Keeney's profile of an amateur as one primarily driven by a desire for self improvement, John and Harvey were clearly interested in adding to the scientific knowledge of the flora of their area. They kept careful records of their botanical observations and noted with great pride the additions to the lists of species known from Bucks County and the Commonwealth of Pennsylvania which resulted from their work. Their botanical specimens are today an integral part of the local herbarium at the Academy of Natural Sciences and are included in the Flora of Pennsylvania Database (Rhoads & Klein 1993) where they contribute to documenting the state flora.

Equally significant is the "snapshot in time" which John Ruth's botanical notes provided. They have given us a unique opportunity to better understand the changes in the flora of northeastern Bucks County over the past 100 years.

ACKNOWLEDGMENTS

We thank librarians at the Academy of Natural Sciences of Philadelphia and the Bucks County Historical Society for their assistance in locating historical documents and Patricia Pingel for help in relocating some of the Ruth brothers' collecting sites.

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Bartonia No. 59: 81-85, 1996

Additions to the Flora of Bradford County, Pennsylvania

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This account lists 80 species, 29 genera, and 2 families as new to Bradford County, Pennsylvania, as well as two species, *Carex crawfordii* and *Carex texensis*, that appear to be new state records. This determination was made from information in a recent floristic atlas (Rhoads & Klein 1993) and an associated database (Pennsylvania Flora Database 1995). Voucher specimens, collected by Naczi in 1990 and by Naczi and Thieret in 1994, have been deposited in the herbarium of the Academy of Natural Sciences of Philadelphia (PH), with duplicates of some collections at Northern Kentucky University (KNK) and the University of Michigan (MICH). Nomenclature largely follows that used in Rhoads & Klein (1993); if we use a different name, the one used there is given in parentheses. Species that apparently have been introduced to Pennsylvania are noted, based on data presented in Rhoads & Klein (1993). Collection numbers in the 2000s are those of the senior author alone; those in the 4000s, of both authors. The following list is alphabetical by family and species.

ACERACEAE. *Acer platanoides*—Towanda, trees to 12 inches DBH, with many smaller ones and saplings, woods along railroad tracks behind Riverside Cemetery, *4242*, 16 Jun 1994, introduced.

APIACEAE. *Aegopodium podagraria* (non-variegated form)—Towanda, wooded drainage area just outside of culvert, behind Riverside Cemetery, *4248*, 16 Jun 1994, introduced. *Anthriscus sylvestris*—ca. 3.3 mi S of West Franklin: roadside, *4269*, 16 Jun 1994, introduced. *Osmorhiza claytonii*—ca. 13 mi SW of Towanda: sugar maple forest, *4296a*, 17 Jun 1994.

ARALIACEAE. *Panax quinquefolius*—ca. 13 mi SW of Towanda, sugar maple forest, *4297*, 17 Jun 1994.

ASTERACEAE. *Artemisia vulgaris*—Sayre, disturbed area in railroad yard, *4329*, 18 Jun 1994, introduced. *Carduus nutans*—ca. 2 mi W of Monroeton, small group of plants at roadside along route 414, *4249*, 16 Jun 1994, introduced. *Hieracium piloselloides*—Towanda, along railroad tracks at railroad station, *4235*, 16 Jun 1994, introduced. *Senecio vulgaris*—Towanda, edge of parking lot, *4286*, 17 Jun 1994, introduced. *Tanacetum vulgare*—Towanda, disturbed area along Susquehanna River at route 6 bridge, *4238*, 16 Jun 1994, introduced. *Tragopogon dubius*—ca. 1.5 mi S of Sylvania, weedy, grassy roadside, *4168*, 15 Jun 1994, introduced. *Tussilago farfara*—ca. 4 mi N of New Albany, roadside, *4140*, 14 Jun 1994, introduced.

BRASSICACEAE. *Arabidopsis thaliana*—Sayre, weedy, gravelly area in railroad yard, *4351*, 18 Jun 1994, introduced. *Coincya monensis* ssp. *recurvata* (*Hutera cheiranthos*)—Towanda, along railroad track at railroad station, *4237*, 16 Jun 1994; west edge of Troy, roadside, *4159*, 15 Jun 1994, introduced. *Nasturtium officinale*—ca. 4 mi SW of Troy, in small stream, *4222*, 15 Jun 1994, introduced. *Sisymbrium loeselii*—Sayre, weedy, gravelly area in railroad yard, *4350*, 18 Jun 1994, introduced.

CABOMBACEAE. *Brasenia schreberi*—ca. 15.5 mi SW of Towanda, many leaves washed up on shore, Sunfish Pond County Park, *4308*, 17 Jun 1994.

CAESALPINIACEAE. *Gleditsia triacanthos*—ca. 11 mi SW of Towanda, two trees at edge of woods, *4316*, 17 Jun 1994.

CANNABACEAE. *Humulus japonicus*—Towanda, disturbed area along Susquehanna River at route 6 bridge, *4239*, 16 Jun 1994, introduced.

CAPRIFOLIACEAE. *Lonicera maackii*—ca. 3.3 mi S of West Franklin, one shrub 12 ft tall, perhaps originally planted, *4267*, 16 Jun 1994, introduced. *Lonicera morrowii*—Troy, lightly shaded stream bank, *4158*, 15 Jun 1994, introduced.

CARYOPHYLLACEAE. *Cerastium glomeratum*—Troy, garden weed, *4157*, 15 Jun 1994, introduced. *Sagina* *procumbens*—Towanda, in lawn at edge of woods, back edge of Riverside Cemetery, *4244*, 16 Jun 1994. *Scleranthus annuus*—ca. 1.5 mi S of Sylvania, roadside, *4167*, 15 Jun 1994, introduced. *Silene antirrhina*—Sayre, weedy, gravelly area in railroad yard, *4348*, 18 Jun 1994, introduced.

CYPERACEAE. *Carex albicans*—ca. 4 mi N of New Albany, mesic deciduous woods, *4133*, 14 Jun 1994. *Carex atlantica* ssp. *capillacea*—ca. 3.4 mi SW of West Franklin, wetland, *4284*, 16 Jun 1994. *Carex blanda*—ca. 2 mi SSE of Towanda, lightly shaded, moist, sandy silt along Towanda Creek, *2615*, 16 Jun 1990; Sayre, weedy, moist area at edge of woods at edge of railroad yard, *4335*, 18 Jun 1994. *Carex bromoides* ssp. *bromoides*—ca. 2.5 mi NW of Franklindale, in alder thicket along stream, *2589*, 15 Jun 1990; ca. 4 mi N of New Albany, mesic deciduous woods, *4134*, 14 Jun 1994. *Carex brunnescens*—ca. 2 mi SSE of West Franklin, swampy red maple/hemlock forest, *2622*, 16 Jun 1990; ca. 5 mi WSW of Troy, moist to wet red maple woods, *4187*, 15 Jun 1994; ca. 4 mi WSW of Troy, roadside in hemlock woods, *4198*, 15 Jun 1994. *Carex crawfordii*—Sayre, weedy, moist area at edge of woods at edge of railroad yard, *4336*, 18 Jun 1994. *Carex glaucodea*—ca. 1.3 mi NW of Franklindale, lightly shaded slope above creek, *2610*, 15 Jun 1990. *Carex gracilescens*—ca. 2.5 mi NW of Franklindale, *2591*, 15 Jun 1990; Sayre, weedy, moist area at edge of woods at edge of railroad yard, *4340*, 18 Jun 1994. *Carex grayi*—ca. 2 mi SSE of Towanda, lightly shaded, moist clay along Towanda Creek, *2620*, 16 Jun 1990. *Carex grisea*—ca. 2 mi SSE of Towanda, lightly shaded, moist, sandy silt along Towanda Creek, *2613*, 16 Jun 1990; Sayre, weedy, moist area at edge of woods at edge of railroad yard, *4347*, 18 Jun 1994. *Carex hirtifolia*—ca. 2 mi NW of Franklindale, mesic deciduous forest near stream, *2596*, 15 Jun 1990. *Carex leavenworthii*—Towanda, edge of woods, back edge of Riverside Cemetery, *4245*, 16 Jun 1994. *Carex mesochorea*—Towanda, edge of woods, back edge of Riverside Cemetery, *4246a*, 16 Jun 1994. *Carex molesta*—Sayre, weedy, moist area at edge of woods at edge of railroad yard, *4337*, 18 Jun 1994. *Carex novae-angliae*—ca. 2.1 mi S of West Franklin, moist red maple/hemlock woods, *2632*, 17 Jun 1990; ca. 5 mi WSW of Troy, moist to wet red maple woods, *4185*, 15 Jun 1994; ca. 4 mi SW of Troy, wet, sunny site near small pond in larch swamp, *4230*, 15 Jun 1994. *Carex pensylvanica*—ca. 2 mi SE of Towanda, rocky, oak/red maple/hemlock forest, *2612*, 16 Jun 1990; ca. 5 mi WSW of Troy, moist to wet red maple woods, *4184*, 15 Jun 1994. *Carex prasina*—ca. 2.5 mi NW of Franklindale, in alder thicket along stream, *2590*, 15 Jun 1990; ca. 4 mi WSW of Troy, in hemlock woods, *4202*, 15 Jun 1994. *Carex sparganioides*—ca. 1.5 mi S of Sylvania, deciduous forest, *4160*, 15 Jun 1994. *Carex stricta*—ca. 3.4 mi SW of West Franklin, large wetland, *4282*, 16 Jun 1994. *Carex tenera*—ca. 1 mi N of Evergreen, moist shallow ditch, *4155*, 14 Jun 1994; Sayre, weedy, moist area at edge of woods at edge of railroad yard, *4346*, 18 Jun 1994. *Carex texensis*—Towanda, moist, shaded lawn, back edge of Riverside Cemetery, *4247*, 16 Jun 1994, probably introduced. *Carex tonsa*—ca. 2 mi S of West Franklin, Barclay Mountain, dry soil among rocks in red maple/white pine woods, *2631*, 17 Jun 1990; ca. 1 mi N of Evergreen, dry rocky roadbank, *4150*, 14 Jun 1994. *Carex willdenowii*—ca. 1.3 mi NW of Franklindale, moist soil on slope above creek, *2608*, 15 Jun 1990; ca. 4 mi N of New Albany, deciduous forest, *4130*, 14 Jun 1994. *Eleocharis acicularis*—ca. 15.5 mi SW of Towanda, forming mats in shallow water along shore, Sunfish Pond County Park, *4312*, 17 Jun 1994. *Schoenoplectus subterminalis*—ca. 15.5 mi SW of Towanda, plant fragments washed up on shore, Sunfish Pond County Park, *4311*, 17 Jun 1994. *Scirpus atrocinctus*—ca. 13 mi SW of Towanda, edge of open, marshy pond, *4305*, 17 Jun 1994.

DROSERACEAE. *Drosera rotundifolia*—ca. 16.5 mi SW of Towanda, in peatland, *4317*, 17 Jun 1994; ca. 4 mi WSW of Troy, shrubby, sunny, wet area with mosses, *4194*, 15 Jun 1994; ca. 3.4 mi SW of West Franklin, wetland, sphagnous, *4280*, 16 Jun 1994.

ERICACEAE. *Rhododendron maximum*—ca. 4 mi S of West Franklin along Schrader Creek, shaded cliffs along creek, *2641*, 18 Jun 1990; ca. 1.7 mi S of West Franklin, edge of depression dominated by shrubs, *4263*, 16 Jun 1994.

FABACEAE. *Coronilla varia*—Towanda, roadside along route 6, *4231*, 16 Jun 1994, introduced.

GERANIACEAE. *Geranium pusillum*—Towanda, weedy lawn along Susquehanna River, *4234*, 16 Jun 1994, introduced.

IRIDACEAE. *Iris pseudoacorus*—ca. 8.5 mi SW of Towanda, sunny, moist roadside, *4292*, 17 Jun 1994, introduced.

JUNCACEAE. *Luzula multiflora*—ca. 4 mi WSW of Troy, shrubby, sunny, wet area, *4195*, 15 Jun 1994.

LAURACEAE. *Lindera benzoin*—ca. 1.7 mi S of West Franklin, swampy area, *4251*, 16 Jun 1994.

LILIACEAE. *Smilacina trifolia*—ca. 1.7 mi S of West Franklin, in shaded sphagnum under shrubs, *4254*, 16 Jun 1994.

LYCOPODIACEAE. *Lycopodiella inundata*—ca. 3.4 mi SW of West Franklin, sandy spots at pond margin, *4273*, 16 Jun 1994. *Lycopodium hickeyi*—ca. 5 mi WSW of Troy, moist to wet red maple woods, *4191*, 15 Jun 1994; ca. 3.4 mi SW of West Franklin, rocky, dryish forest, *4270*, 16 Jun 1994.

LYTHRACEAE. *Decodon verticillatus*—ca. 3.4 mi SW of West Franklin, in shrubby wetland, *4278*, 16 Jun 1994.

MENYANTHACEAE. *Menyanthes trifoliata*—ca. 3.4 mi SW of West Franklin, in shrubby wetland, *4269a*, 16 Jun 1994.

NYMPHAEACEAE. *Nymphaea odorata*—ca. 15.5 mi SW of Towanda, in shallow water, Sunfish Pond County Park, *4313*, 17 Jun 1994.

PINACEAE. *Picea abies*—ca. 3 mi S of West Franklin, uneven-aged and -sized trees, reproducing, in disturbed woods, *4264*, 16 Jun 1994, introduced. *Picea glauca*—ca. 3 mi S of West Franklin, uneven-aged and -sized trees, reproducing, in disturbed woods, *4265*, 16 Jun 1994, introduced. *Picea rubens*—ca. 3.4 mi SW of West Franklin, moist forest, *4277*, 16 Jun 1994.

POACEAE. *Avena sativa*—Wysox, disturbed area, *4352*, 18 Jun 1994, introduced. *Lolium perenne*—Towanda, along railroad tracks at railroad station, *4236*, 16 Jun 1994, introduced.

POTAMOGETONACEAE. *Potamogeton epihydrus*—ca. 15.5 mi SW of Towanda, plant fragments washed up on shore, Sunfish Pond County Park, *4315*, 17 Jun 1994.

PRIMULACEAE. *Lysimachia thyrsiflora*—ca. 16.5 mi SW of Towanda, peatland, *4327*, 17 Jun 1994.

RANUNCULACEAE. *Ranunculus bulbosus*—ca. 2 mi S of Sylvania, moist, shady roadside, *4176*, 15 Jun 1994, introduced. *Ranunculus repens*—ca. 4 mi WSW of Troy, shady, wet roadside, *4207*, 15 Jun 1994, introduced.

ROSACEAE. *Geum rivale*—ca. 4 mi SW of Troy, larch swamp, *4223*, 15 Jun 1994. *Sorbaria sorbifolia*—ca. 3 mi S of West Franklin, large colony for ca. 30 m along roadside, perhaps from original planting, *4266*, 16 Jun 1994, introduced.

SAXIFRAGACEAE. *Saxifraga pensylvanica*—ca. 4 mi SW of Troy, larch swamp, *4224*, 15 Jun 1994.

SCROPHULARIACEAE. *Chaenorrhinum minus*—ca. 8 mi SW of Towanda, roadside, *4290*, 17 Jun 1994, introduced. *Melampyrum lineare* var. *americanum*—ca. 1.5 mi S of Sylvania, rocky roadbank at edge of mixed woods, *4164*, 15 Jun 1994. *Veronica peregrina*—Towanda, along railroad track behind Riverside Cemetery, *4243*, 16 Jun 1994.

SIMAROUBACEAE. *Ailanthus altissima*—Towanda, bluff along Susquehanna River, *4232*, 16 Jun 1994, introduced.

DISCUSSION

Of the 80 species we report as new to Bradford County, 47 (59%) are native to Pennsylvania and 33 (41%) are introduced to the state. The total number of species and infraspecific taxa previously recorded from Bradford County is 899, of which 712 (79%) are native and 187 (21%) are introduced (Pennsylvania Flora Database 1995). Including our discoveries, 979 total species and infraspecific taxa are now recorded for the county, with 759 (78%) natives and 220 (22%) exotics. The large proportion of introduced species among our county records indicates at least two things. First, introduced plants probably have been neglected in previous botanical exploration of the county. Second, such species probably have increased in importance in the flora in recent time. *Acer platanoides*, *Anthriscus sylvestris*, *Carduus nutans*, *Coincya monensis* (*Hutera cheiranthos*), and *Lonicera morrowii* may be recent invaders of Bradford County. Rhoads and Klein (1993) include these exotics in a list of species that apparently are spreading within Pennsylvania. A large proportion of the natives (22 of 47, or 47%) are members of *Carex*, the most species-rich and taxonomically complex genus of vascular plants in Pennsylvania. Many field botanists avoid collecting *Carex* plants because they believe them to be too difficult to identify. Thus, neglect of these plants in past collecting in Bradford County probably accounts, at least somewhat, for the large number of *Carex* species among our records.

Many of our county records, both natives and exotics, are quite expected. Such species as *Carex bromoides*, *C. pensylvanica*, *C. prasina*, *Drosera rotundifolia*, *Lindera benzoin*, *Osmorhiza claytonii*, *Potamogeton epihydrus*, *Rhododendron maximum*, and *Tussilago farfara* are recorded from adjacent counties, often commonly (Rhoads & Klein 1993). Other records are rather surprising. Two of the county records listed in this paper are apparently new state records. *Carex crawfordii* has been reported from Pennsylvania (Rhoads & Klein

1993) based on one collection [Pike Co.: Twin Lakes, *Bright 19320*, 29 Jun 1944, two sheets at herbarium of Carnegie Museum of Natural History (CM)]. These specimens were recently re-determined by Anton A. Reznicek as the common *Carex scoparia* Schk. (A.A. Reznicek pers. comm.; S. Thompson pers. comm.), eliminating *C. crawfordii* from the recorded flora of Pennsylvania. Thus our collection (also determined by Reznicek) appears to be the first of *C. crawfordii* from the state. *Carex texensis* also appears to be a new state record; it is not included by Rhoads & Klein (1993).

Though *C. texensis* is native in the eastern United States (Gleason & Cronquist 1991), this species is probably not native to Pennsylvania. *Carex texensis* is a weedy species that often invades lawns (Waller 1929). Its geographic range seems to be expanding northward and eastward, often in cemetery lawns (A.A. Reznicek pers. comm.), the habitat in which we found it. Like *C. texensis, C. crawfordii* is native in the eastern United States, but farther north (mostly north of Pennsylvania). Though we collected it with several introduced species in a disturbed area at the edge of a railroad yard, it is likely native to Pennsylvania. Evidence for this contention includes (1) the frequent occurrence of native populations of *C. crawfordii* in disturbed areas (A.A. Reznicek pers. comm.), (2) its occurrence in three counties of nearby New Jersey, all farther south than our locality (Hough 1983), and (3) its occurrence in Tioga County, New York, which borders Bradford County on the north (New York Flora Association 1990).

Carex glaucodea, C. leavenworthii, C. mesochorea, and *C. willdenowii* are somewhat disjunct from their other Pennsylvania occurrences. *Carex glaucodea* and *C. willdenowii* are near the northern limits of their ranges, at which their populations are quite scattered (Naczi pers. observation). Interestingly, *C. leavenworthii* and *C. mesochorea* occurred in the same cemetery lawn as *C. texensis.* Like *C. texensis,* these species appear to be expanding their ranges; they may be adventive in Bradford County.

Our discoveries of *Coincya monensis* and *Sisymbrium loeselii* are surprising, too. Rhoads & Klein (1993) record the introduced *C. monensis* from only Clearfield and Luzerne counties, but they report that it is expanding its range and suggest that it is probably more frequent than herbarium records indicate. Our two collections from Bradford County support this suggestion. Previously, *S. loeselii* was known in Pennsylvania from only Pike County, apparently from one population (Rhoads & Klein 1993). Gleason & Cronquist (1991) comment that this native of southeastern Europe and western Asia is only "occasionally found in our range."

Most of the species recorded in this paper are infrequent to abundant in Pennsylvania, but three are plants listed or proposed for listing under the Pennsylvania Wild Plant Conservation Act: *Carex crawfordii, C. mesochorea,* and *Panax quinquefolius* (Rhoads & Klein 1993).

We gathered a wealth of county records in only 7 days in a brief period of late spring. Apparently, floristic knowledge of Bradford County had been rather incomplete prior to our collecting. The county's flora is better known, and further exploration will doubtless yield more records.

ACKNOWLEDGMENTS

We thank Dr. Ann Fowler Rhoads (Morris Arboretum) for providing a list of the plant taxa previously recorded from Bradford County and various statistics describing them, all from the Pennsylvania Flora Database; Dr. Anton A. Reznicek (University of Michigan) for identifying some of our sedge specimens and sharing his knowledge of sedge distribution, ecology, and literature; and Dr. Alfred E. Schuyler (Academy of Natural Sciences of Philadelphia) for determination of a specimen of *Scirpus*. The late A. B. Cox showed the senior author many Bradford County habitats that proved fruitful in the search for noteworthy records. National Science Foundation doctoral Dissertation Improvement Grant BSR-9001260 provided financial support for the 1990 field work; Northern Kentucky University's Department of Biological Sciences and Office of Research, Grants, and Contracts contributed financially to the 1994 field work.

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Bartonia No. 59: 87-93, 1996

Population Study of *Eriophorum gracile* Koch (Cyperaceae) at its Southern Range Limit in Pennsylvania

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In 1989 a new population of *Eriophorum gracile* Koch was found in northeastern Pennsylvania in Pike County. It has been found at three other sites since 1988; however, it was reported extirpated at twenty-two historical sites (Pennsylvania Natural Diversity Inventory). A similar trend is occurring in New Jersey, with one possible extant population and at least nine historical. The range of *E. gracile* is circumboreal and extends south in North America to Pennsylvania, New Jersey, Indiana, Iowa, Colorado, and California (Gleason & Cronquist 1991). Its southern limit closely follows that of northern dwarf-shrub bogs and the terminal moraine of the Wisconsin glaciation which retreated approximately 20,000 years ago (Lynn & Karlin 1985). *Eriophorum gracile* is classified as endangered in Pennsylvania by the Pennsylvania Department of Environmental Resources (Commonwealth of Pennsylvania 1993).

Because Pennsylvania represents part of the southern limit of the plant's geographical range, the question arises: Are factors associated with the habitats at the southern limit of this species' range reducing the fecundity and/or genetic composition of these populations causing the species to become rare? Because both reduced fecundity and genetic diversity can limit a population's ability to rebound from extirpation, these two parameters were investigated using the newly-found Pennsylvania population of *E. gracile*. Genetic diversity was measured using allozyme electrophoresis. Because comparisons between congeneric species have been shown to be illustrative of the causes and consequences of biological rarity and commonness (Pleasants & Wendel 1989; Cabin et al. 1991; Standley & Dudley 1991; Standley et al. 1991) reproductive success was investigated here by comparing seed set between *E. gracile* and *E. virginicum* L., a species which also grows in Smith's Swamp bog.

There are numerous possible causes behind the loss of *E. gracile* from its historical sites. The first, physical disturbance, is a strong possibility considering the extensive development in the northeastern United States and the evidence of physical disturbance completely eliminating some bog habitats and their associated plants. Sites that have undergone disturbance in the form of beaver damming, man-made damming, road building, construction, peat mining, etc., can experience ecological changes such as increased sedimentation, altered water flow and nutrient flux, and actual habitat elimination making the area unsuitable for *E. gracile* survival. Stewart & Nilsen (1993), in a vegetative comparison of five bogs in West Virginia and Tennessee, observed that the one site impacted by agricultural fields, with resultant higher nutrient levels than the other four sites, was the only one that did not contain *Eriophorum virginicum*, another bog sedge, and other species associated with more nutrient-poor bogs. A second possibility is that the historic populations were sink populations (sensu

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Pulliam 1988) dependent upon outside source populations for recruitment. If a change in propagule dispersal from source to sink occurred, the sink population could die out. A third possibility is that succession, either on a site-specific or regional scale (such as occurs with the retreat of glaciers and the associated climatic changes) is affecting the habitat suitability for *E. gracile*. Populations at geographical limits would seem to show the effects of climatic changes more noticeably than those more centrally located. Although the literature on the ecological consequences of populations at their geographical limits is sparse, those studies that have been performed implicate both biological and climatic causes of rarity (Pigott & Huntley 1978, 1981; Weis & Hermanutz 1988; Pigott 1989; Neilson & Wullstein 1983; Houle & Bouchard 1990; Cabin et al. 1991). Finally, these habitats might be inferior in quality to other, more centrally-located areas, resulting in reduced fecundity and genetic variability of the populations, and making them more susceptible to extirpation by stochastic events. It is this last theory which I chose to investigate.

The study site is a glacial kettlehole bog approximately one hectare in size in Pike County, Pennsylvania (Table 3). It is surrounded by a large highbush blueberry (*Vaccinium corymbosum*)—red maple (*Acer rubrum*) swamp. The bog shows clear concentric zonation from larch (*Larix laricina*) and black spruce (*Picea mariana*) at the periphery, grading to a grounded bog mat dominated by leatherleaf (*Chamaedaphne calyculata*) and *Sphagnum* spp., to a floating mat of sedges (*Carex canescens*, *Carex limosa*, *Rhynchospora alba*, and *Eriophorum gracile*) along with *Xyris montana* and *Sphagnum* spp. (*Sphagnum cuspidatum*, *S. fallax*, *S. magellanicum*, and *S. recurvum*), and finally to an area of open water roughly 30 m across. Shrubs are low, and the few trees that are in the bog are generally not over 2 m. *Eriophorum gracile* occurs as a pioneer species estimated at 5000 individuals at the edge of the open water in dense clumps and forms a floating mat of vegetation. Individuals nearer the mat of *Sphagnum* and *Chamaedaphne* are partially rooted in the substrate, and are scattered throughout this mat. The pH of water in the floating mat is about 4.0, and the whole bog is exposed to full sun.

METHODS

DENSITY COUNTS. Density counts along a microsite gradient were taken from m^2 quadrats along a 6 m long transect during the period of May 25—July 14, 1991. The transect ran from grounded bog mat containing *Chamaedaphne calyculata*, and *Sphagnum* spp., to open water, to a small grounded island ~2m in diameter containing *C. calyculata* and two small trees of *Larix laricina* and *Picea mariana*, each approximately 2 m in height. The transect then ran back to open water. Numbers of vegetative and flowering shoots were recorded for each quadrat and compared to microsite type which was either grounded bog mat dominated by shrubs of *C. calyculata* and *Sphagnum* spp., open water, or a combination of both. This was done to determine any differences in plant densities between microsites, and thus microhabitat preference of *E. gracile*. Associated species in each quadrat were also recorded.

ENZYME ELECTROPHORESIS. Leaf material was collected from 5 plants each in 5 semi-distinct clumps of plants around the bog. Well-spaced, selected samples were taken unsystematically in early September 1992 from each clump in order to maximize the likelihood of sampling all genotypes in the population. Starch gel electrophoresis was run on fresh and frozen material following the protocol of Soltis et al. (1983). Frozen samples were quick-frozen in liquid nitrogen then stored at -80°F. Gels were stained for alcohol dehydrogenase (ADH), malate dehydrogenase (MDH), phosphoglucoisomerase (PGI), 6-

phosphogluconate dehydrogenase (6-PGD), fructose-1,6-diphosphatase (F-1,6-DP), shikimate dehydrogenase (SKDH), adolase (ALD), and glutamate oxaloacetate transaminase (GOT). The first five ran on a discontinuous citric acid-histidine-HCl buffer system; SKDH and ALD ran on a continuous tris-citric acid buffer system; and GOT ran on a discontinuous lithium borate and tris-citrate buffer system. All buffer system recipes came from Soltis et al. (1983). Staining recipes for PGI, 6-PGD, ALD, F-1,6-DP, MDH, and SKDH were obtained from Soltis et al. (1983); that for ADH from Vallejos (1983); and that for GOT from Harris & Hopkinson (1976). All putative loci were consistently scorable across all gels. All enzymes were interpreted as dimeric except ALD which was tetrameric, and SKDH, which was monomeric.

FECUNDITY. Twenty-seven inflorescences were collected from the same 5 clumps as the leaf material on July 14, 1991 after fruit was set and spikelets were just beginning to disassociate. These were dissected by spikelet. From these spikelets, numbers of spikelets per reproductive ramet, total numbers of flowers (determined after the flowers had senesced by counting the persistent scales, each of which originally subtended a single flower), total numbers of presumed seeds (determined by enlarged ovaries), and the total maximum number of presumed viable seeds (determined from visual inspection of the seeds—those that were at a minimum 3/4 swollen with a hard seed and containing white-colored (as opposed to yellow or dark) endosperm were judged to be filled and potentially viable) were counted. Potential viability, which was calculated as the number of flowers produced per reproductive ramet, and actual viability, which was calculated as the maximum number of potentially filled seeds per reproductive ramet, were determined. From these measures, average potential viability, average actual viability, and average total percent viability (actual seed set/potential seed set) were then calculated.

RESULTS

DENSITY COUNTS. The density counts, habitat types, and list of associated species of each quadrat are listed in Table 1. In numbers of vegetative shoots, the plant clearly grew better in the open water microsite, confirming its role as a pioneer species. Numbers of flowering shoots did not directly reflect the microsite type except that there were no flowering shoots on the quadrat that was completely on the grounded mat; thus effect of microsite on total fitness of the plant is not certain, except that little growth—vegetative or reproductive—occurred on the completely grounded mat.

ENZYME ELECTROPHORESIS. The eight enzymes that stained showed no variation in putative loci among the 25 plants. Two enzymes, ADH, and SKDH, were polymorphic and heterozygous indicating that the population sampled is homogeneous.

FECUNDITY. Of 2517 flowers examined, only 116 actually developed into potentially viable seeds resulting in an actual fecundity of 4.3 viable seeds/plant (Table 2). The actual fecundity may be even lower as the assessment of potentially viable seeds was done conservatively. This is in sharp contrast to *Eriophorum virginicum* which had an actual fecundity of 200 viable seeds/plant. While the number of *E. virginicum* plants with intact spikelets used was only one compared to 27 of *E. gracile*, examples of a number of partially fallen apart *E. virginicum* spikelets showed that nearly all scales contained a swollen, hard seed. This was never seen with *E. gracile* spikelets. Total percent fecundity was 4.6% for *E. gracile* and 87.3% for *E. virginicum*.

Table 1. Density counts per m^2 of *E. gracile* along a 5 m long transect of microsite gradients and associated species.

Quad.[1]	No. of Shoots[2]			Habitat Type	Associated Species
	Veg.	Flow.	Total		
1	169	15	184	Half grounded mat, half open water	*Chamaedaphne calyculata, Sphagnum* spp., *Carex canescens, Calla palustris, Carex limosa*
2	586	12	598	Open water	*Utricularia* sp., *Calla palustris*
3	101	0	101	Island grounded mat	*Chamaedaphne calyculata, Sphagnum* spp., *Carex canescens, Carex limosa*
4	53	10	63	Partial island grounded mat, mostly open water	*Chamaedaphne calyculata, Carex limosa, Carex canescens, Sphagnum* spp., *Xyris montana Rhynchospora alba, Drosera rotundifolia, Drosera intermedia*
5	183	7	190	Open water	*Carex limosa, Carex canescens, Drosera intermedia, Chamaedaphne calyculata* (juv.)

[1]Quadrat no.
[2]Veg. = No. of vegetative shoots, Flow. = No. of flowering shoots, Total = Total number of shoots.

Caution must be used comparing different species. *E. virginicum* shoots grow widely separated from each other and the species does not appear to be clonal at this site. These factors may cause it to rely more strongly on seed production and/or on longer rhizomes than *E. gracile*, therefore the two species may have differing growth and reproductive strategies, and different morphologies.

Table 2. Quantitative seed data of *Eriophorum gracile* compared with *E. virginicum*.

	E. gracile	*E. virginicum*
Total no. reproductive ramets	27	1
Total no. spikelets	86	7
Total no. flowers	2517	229
Total no. seeds produced	1456	200
Total max no. filled seeds	116	200
Avg. no. spikelets/reproductive ramet	3.2	7
Avg. potential viability (no. flowers/reproductive ramet)	93.2	229
Avg. actual viability (max. no. filled seeds/reproductive ramet)	4.3	200
Avg. total % viability ([actual viability/potential viability] × 100)	4.6	87.3

DISCUSSION

Allozyme results show that all 25 individuals examined were homozygous for 6 loci and heterozygous with the same alleles for ADH and SKDH, suggesting that the population of *Eriophorum gracile* might have been established from a single founder individual. The homogeneity of allozyme loci and the low rate of seed set compared to its congener *E. virginicum* also indicate that genetic self-incompatibility mechanisms might be operating in this species. Self-incompatibility with lack of exogenous pollen flow could lead to the absence of successful sexual reproduction. Because the Smith's Swamp population is iso-

Table 3. Extant and Historical Sites of *Eriophorum gracile* Koch. in Pennsylvania, recorded by herbarium specimens.*

Pike County. Extant site 2.1 km N of Lords Valley, Smith's Swamp: bog, very edge of *Sphagnum* mat with Carex limosa, 13 May 1991, C. Barr, PH; edge of *Sphagnum* mat with *Carex limosa*, 13 May 1991, C. Barr, PH; edge of bog, with *Carex limosa* and *Sphagnum*, 16 May 1991, C. Barr, PH; abundant at edge of mat and in open water with *Carex limosa*, 16 May 1991, A. Rhoads, MOAR; in open water adjacent to bog mat, with *Carex canescens* and *Carex limosa*, abundant, 16 May 1991, A. Rhoads, MOAR.

Bucks County. Argus [Bucks and Montgomery cos.], 3 May 1893, J. Crawford, PH. Nockamixon Rocks, Narrowsville, in a meadow, 30 May 1893, B. Heritage, PH; 30 May 1893, S. Brown, PH; 30 May 1893, C.D. Lippincott, PH; bog near Nockamixon Cliffs, 30 May 1893, T. C. Porter, PH; 30 May 1893, S. Brown, PENN. Ca. 1.5 mi NW of Pleasant Valley, boggy swale, head of tributary of Cooks Creek, 9 Jun 1923, B. Long, PH. Quakertown, tunnel [prob. same as Rockhill], 16 Jun 1866, I.C. Martindale, PH; near Quakertown [prob. same as Rockhill], 3 Jun 1894, S. Brown, PH; Quakertown [prob. same as Rockhill], 3 Jun 1894, S. Brown, PENN; Rockhill, Jul 1881, C.D. Fretz, PH; 1 Jun 1890, J.B. Brinton, PENN; bog, 31 May 1903, A. MacElwee, PH; 30 May 1906, S. Brown PENN; 30 May 1906, E.B. Bartram, PENN; small bog rt. of RR above station, 30 May 1906, S.S. VanPelt, PH. Sellersville, 1866, A.P. Garber, PH; near Sellersville, on trap rock range, N. Penn RR, abundant, Jun 1866, I.C. Martindale, PH. Springfield Township [prob. same as Pleasant Valley], 5 Jun 1899, C.D. Fretz, PH.

Montgomery County. No locality or date, A.P. Garber, PH. Sassamansville, 31 May 1910, J.M. Mumbauer, PH.

Delaware County. Rhodes Swamp, Marple, swamp above Rhodes' [Tan?] yard, undated, A.H. Smith, PH; Rhodes Swamp, Marple, undated, A.H. Smith, PH; Rhodes Swamp, Springfield, Jun 1864, C.E. Smith, PH; Rhodes Swamp, Marple, 18 May 1865, T.C. Porter, PH; Rhodes Swamp, Marple, Springfield Township, Jun 1865, A.H. Smith, PENN.

Berks County. 0.25 mi N of Gouglersville, rare and local in bog, 24 May 1941, W. Wilkens, PH; 0.5 mi N of Gouglersville, alt. 700 feet, marsh, 23 May 1943, D. Berkheimer, CM. Lobachsville, bog, 27 July 1915, B. Long, PH. Seiningers Swamp, Spring Township, 14 May 1881, T.J. Oberly, PH.

Northampton County. Hellertown, 1863, T.C. Porter, PH. Johnsonville, wet meadows along trolley road, 30 May 1908, C.S. Williamson, PENN; Johnsonville, bog south of RR, 0.25 mi E of station, 31 May 1908, S.S. VanPelt, PH; 0.25 mi E of Johnsonville, along DL&W RR, 5 Jun 1910, H.W. Pretz, PH. Mount Bethel, 31 May 1908, E. B. Bartram, PH. Williams Township, meadow, 4 Jun 1868, T.C. Porter, PH.

Lehigh County. Allentown, 3.25 mi SSW of Center Square, open, marshy spring partly scrubby place along south side of stream, 2 Jun 1935, H.W. Pretz, PH. 1.5 mi E of Center Valley, meadows along streamlet, 9 Jun 1912, H.W. Pretz, PH. 2.5 mi ESE of Hosensack, below Swamp Church, swampy place along county line road, 21 May 1911, H.W. Pretz, PH. 2.13 mi SSE of Limeport, marshy meadows heading Licking Creek, 14 Jun 1914, H.W. Pretz, PH. 0.75 mi NNE of Sigmund, in a meadow beside Indian Creek, 25 Jun 1916, H.W. Pretz, PH. Sigmund, open marshy meadows north of road just east of Sigmund PO (Hampton Furnace), 17 Jun 1923, H.W. Pretz, PH. About 1 mi SSE of Spring Valley, in the meadows along streamlet on Triassic ridge [could be same as Center Valley], 13 May 1911, H.W. Pretz, PH.

Warren County. Extant site near Columbus, Toplovich Bog, small kettle pond (less than .1 acre) surrounded by *Chamaedaphne*, 29 May 1990, J.K. Bissell et al., CLM. Extant site about 1.7 km N of Columbus, small stand in open wet peaty depression fed by seep at base of low slope, 25 Aug 1993, A.E. Schuyler 7837, PH.

Erie County. One extant site at Edinboro Lake, N shore, fen meadow shrub thickets along fen spring channel on embankment, 21 Jul 1988, J.K Bissell et al., CLM; *Carex* hummocks along W side of channel within center of fen, 10 Jun 1989, J.K. Bissell et al., CLM. Presque Isle, 30 May 1879, G. Guttenberg, CM; Presque Isle, N Misery Bay, wet meadow, J. Miller, CM.

*Abbreviations of herbaria are those of Holmgren et al. 1990.

lated from other conspecific populations, wind- or insect-mediated exogenous pollen flow is likely to be limited to nonexistent. The presence of *E. gracile* filled seeds, though low in number, and of marginal quality, might be explained by apomixis. Alternatively, self-compatibility with lack of subsequent seedling establishment could also explain the results.

Suboptimal habitat quality may also be affecting reproductive capability. Habitats south of the Wisconsin terminal moraine do not have the qualities of the glaciated region; even habitats at the edge of the moraine could experience southern influences. Clonal structure itself may limit successful fertilization in self-incompatible species (Handel 1983; Aspinwall & Christian 1992), however other factors such as temperture-limited ovule development, insufficient time to mature fruits due to short growing seasons, and decreased pollen viability and/or volume have been implicated as reducing successful sexual reproduction of a northern clonal plant species (Weis & Hermanutz 1988) and could also be acting at other range limits.

Eriophorum gracile in this habitat is likely to be in an early vegetatively colonizing stage and its survival depends upon a stable habitat until the population develops adaptive genetic variability. However, because the *E. gracile* population studied is farily isolated from other conspecific populations, the chance for building variability by combination of alleles is drastically reduced.

Further research is needed to determine the causes of extirpation of *E. gracile* at its southern limit. It is first necessary to perform comprehensive site surveys of all historical sites to verify that *E. gracile* is surely gone from them. Table 3 lists herbarium specimen data of *E. gracile* from Pennsylvania with indications whether it is extant or extirpated at sites where it was previously collected. Repeating the same experiments performed in this study on peripheral and more centrally-located populations and comparing the results obtained there would be useful to determine whether low fecundity and low genetic variability are correlated with the southern limit. Investigating the breeding and dispersal systems of *E. gracile* would be extremely useful for clarifying the genetic and reproductive dynamics of the populations. Finally, comparative water and substrate chemistry analyses of the habitats that have lost *E. gracile* with habitats supporting vigorous populations could indicate possible environmental changes that are associated with extirpation.

ACKNOWLEDGMENTS

I thank Drs. Ann Rhoads, Brenda B. Casper, and Alfred E. Schuyler for all their help, resources, and inspiration. I also thank the Pennsylvania Department of Environmental Resources for access to my study site, the Pennsylvania Chapter of The Nature Conservancy for invaluable information, and E. Karlin for identifying *Sphagnum*.

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Bartonia No. 59: 95-96, 1996

Taxonomic Status of *Panicum hirstii* Swallen

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Panicum hirstii Swallen was first collected in Sumter County, Georgia, in 1900 and "doubtfully referred to" *Panicum roanokense* Ashe a decade later (Hitchcock and Chase 1910). In 1958 it was discovered in Atlantic Count, New Jersey, and described as a new species soon afterward (Swallen 1961). More recently, *P. hirstii* was considered to be a probable "glabrous variant of *Panicum neuranthum* Griseb." (Kral 1983) or conspecific with *Panicum aciculare* Desv. (Gleason and Cronquist 1992). In order to determine if *P. hirstii* warrants recognition as a species, I studied plants identifiable as it, *P. roanokense*, *P. neuranthum*, and *P. aciculare* in the field and herbarium in 1993. Plants of *P. hirstii* and *P. roanokense* were examined in the field in Sussex County, Delaware, *P. aciculare* in Wicomico County, Maryland, and *P. neuranthum* in Baker County, Georgia. Numerous herbarium specimens of all taxa were examined in collections at the Academy of Natural of Sciences (PH), New York Botanical Garden (NY), Smithsonian Institution (US), and Vanderbilt University (VDB).

As do its relatives, *P. hirstii* produces erect leafy stems with terminal inflorescences early in the season, then develops axillary shoots with inflorescences later in the season, and finally persists as low over-wintering leafy rosettes close to the ground. The axillary shoots are sparingly branched and not much reduced. The slender plants grow to about one meter tall and have narrow inflorescenes with upwardly appressed branches. The pedicels are less than twice as long as the glabrous elliptic spikelets. The first glume is short and broadly obtuse, the second glume and sterile lemma have nine nerves, and a hyaline sterile palea is present. The plants grow in ponds or on pond bottoms with sandy peaty substrates, which intermittently have standing water. Considerable water level fluctuation may occur throughout the growing season.

Panicum hirstii is more similar to *P. roanokense* than to any other described taxon. The latter is considered conspecific with *Panicum* (*Dichanthelium*) *dichotomum* by some authors (Gleason and Cronquist 1992; Gould and Clark 1978). Both *P. hirstii* and *P. roanokense* have glabrous spikelets about the same size, both have about equally prominent nerves in the leaves, second glumes, and sterile lemmas, and both have similar hyaline sterile paleas. *Panicum roanokense* is readily distinguished from *P. hirstii*, however, by having more branched and reduced axillary shoots, more open inflorescences with pedicels often twice or more as long as the spikelets, and more variation the number of nerves (7-9) in the second glumes and sterile lemmas. Instead of ponds or pond bottoms, *P. roanokense* is found in swales, meadows, swamps, and low woods (Fernald 1950; herbarium specimen data).

Panicum hirstii bears a superficial resemblance to *P. neuranthum*, which is considered conspecific with *Panicum* (*Dichanthelium*) *aciculare* by some authors (Gould and Clark 1978). The following characters that distinguish *P. hirstii* and *P. neuranthum*, also effectively distinguish *P. hirstii* and *P. aciculare* sensu stricto. The inflorescences of *P. neuranthum* may be narrow with upwardly appressed branches and resemble those of *P. hirstii* to some extent. Plants with open inflorescences, however, may grow in the same populations with plants having upwardly appressed inflorescenes. In contrast to *P. hirstii*, *P. neuranthum* often has pedicels over twice as long as the spikelets and also has much more prominent nerves in the leaves, second glumes, and sterile lemmas. It further differs from *P. hirstii* by having pubescent spikelets, seven instead of nine nerves in the second glumes and sterile lemmas, and no sterile paleas. The habitat is drier with *P. neuranthum* more often found in savannas (Hitchcock and Chase 1910) and low sandy peaty areas that are intermittently wet (herbarium specimen data). It is not known from ponds or pond bottoms although it may occur in low areas adjacent to ponds.

No apparent infraspecific variation was encountered in specimens of *P. hirstii* throughout its limited range from New Jersey to Georgia. Its range within the four states from which it is known is very local: two sites in Atlantic County, New Jersey; one site in Sussex County, Delaware; two sites in Onslow County, North Carolina; one site in Sumter County, Georgia; and one site in Calhoun County, Georgia (data from herbarium specimens at NY, PH, and US). Its limited occurrence may be attributed to its specialized habitat in ponds characterized by considerable water-level fluctuation.

ACKNOWLEDGMENTS

Dana Peters arranged for this study to be funded by the U.S. Fish and Wildlife Service. Patricia Holmgren (New York Botanical Garden), Warren Wagner (Smithsonian Institution), and Robert Kral (Vanderbilt University) provided access to herbarium specimens at their respective institutions. For help, directions, and/or guidance with field work, I thank Jim Allison, Frank Hirst, Robert Kral, William McAvoy, Robert Norris, Tom Patrick, Patricia Schuyler, and Ron Wilson. Terrance Mann prepared the manuscript for publication.

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Bartonia No. 59: 97-106, 1996

Soil Chemistry Data for Species of Special Concern in Pennsylvania

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While most vascular plants in Pennsylvania were described over 100 years ago, I am unaware of any single source for detailed habitat requirements for these species. With the increasing emphasis on habitat creation and restoration, and reintroduction projects, soil chemistry characteristics for individual species becomes increasingly important for successful plantings. This may be especially true for rarer species, since generally they either have limited habitat within the state or their habitat requirements are very narrow. Unfortunately, definitive soil chemistry data for most species are limited or nonexistent.

Over the last 15 years, I have collected, and have had analyzed, soil samples from 360 sites in eastern Pennsylvania (as far west as Fulton and Tioga counties) and Central and Southern New Jersey. These samples were collected as parts of various studies for Bowman's Hill Wildflower Preserve Association, the Pennsylvania Department of Environmental Resources (as part of the field team for Morris Arboretum of the University of Pennsylvania and separately), the National Park Service study of the Upper Delaware Scenic and Recreational River (Morris Arboretum), and numerous individual consulting wetlands projects.

METHODS

Soil was collected from the root zone adjacent to the species listed. This zone varied, depending on the habitat, from barely decayed peat in bogs, to the "Ao" horizon, the "A" horizon and occasionally the "B" or "C" horizons in disturbed areas. The soils were stored in plastic bags, then air dried, screened and sent to the Agricultural Analytical Services Laboratory (formerly known as the Merkle Laboratory) at The Pennsylvania State University, University Park, Pennsylvania. The laboratory tested for calcium, magnesium and potassium (exchangeable cations [milli-equivalents/100 grams] and percent base saturation), phosphorus (pounds/acre), pH, cation exchange capacity and organic matter (ash combustion). Over the years of collecting data, the method of measuring organic matter changed from a titration method, which had limited accuracy over about 5 percent, to an ash combustion technique, which is currently used. Therefore, all pre-ash combustion data were eliminated from calculations and left blank in Table 1. The nomenclature follows Rhoads & Klein (1993), except for *Dodecatheon amethystinum*, which follows Gray's Manual (Fernald 1950).

RESULTS

A partial list of Pennsylvania endangered, threatened and extirpated plants and the soil chemistry data collected for each are given in Table 1. Since these are very rare species, multiple sites were not always available. Therefore, the data should be considered as preliminary. Locality information for the sample sites is given in Table 2.

ACKNOWLEDGMENTS

I thank the Bowman's Hill Preserve Association, Dr. Ann Rhoads and others at the Morris Arboretum, the Pennsylvania Department of Environmental Resources, and Ann Newbold for verifying the identification of the rare plants.

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Table 1. Soil chemistry data for plants of special concern in Pennsylvania.

Species	Sta[a] (*N*)[b] Loc[c]	pH	lbs/ac P	% K	% Mg	% Ca	meq/100g K	meq/100g Mg	meq/100g Ca	meq/100g CEC	% Org
Amelanchier bartramiana	E (6)	4.0±0.2	173±87	2±1	4±1	10±4	0.60±0.26	0.9±0.2	2.5±0.9	25.1±5.0	93±5
	40, 42	3.7-4.3	42-293	1-4	2-5	6-15	0.34-1.10	0.6-1.3	1.5-4.5	17.7-31.2	82-97
Arabis missouriensis	E	4.8	122	2	5	17	0.34	0.9	3.0	18.1	21
	47										
Arethusa bulbosa	E	4.0	6	0	4	7	0.07	0.6	1.2	18.2	76
	65										
Asplenium bradleyi	T	3.8	80	1	2	1	0.24	0.3	0.2	17.1	43
	29										
Asplenium resiliens	E (2)	7.4±0.1	36±6	3±1	31±1	67±2	1.05±0.05	10.5±2.0	23.5±5.5	30.2±2.4	22±5
	27	7.2-7.5	30-42	2-4	30-31	65-68	1.00-1.10	8.5-12.5	18.0-29.0	27.8-32.5	17-27
Aster depauperatus	T (2)	6.5±0.5	7±1	1±0	80±4	13±3	0.18±0.03	13.0±2.0	2.0±0.0	16.1±3.3	10±2
	21, 25	6.0-7.0	6-8	1-1	76-83	10-16	0.15-0.20	11.0-15.0	2.0-2.0	12.7-19.4	8-11
Aster novi-belgii	T (2)	4.1±0.4	20±15	1±0	3±1	5±3	0.16±0.05	0.5±0.0	1.4±1.1	23.2±9.7	33±5
	3	3.7-4.5	5-34	1-1	2-4	2-8	0.11-0.20	0.5-0.5	0.3-2.5	13.5-32.9	28-38
Aster spectabilis	E (3)	5.7±0.4	19±10	1±0	8±5	36±13	0.06±0.00	0.6±0.4	2.5±1.0	7.3±0.6	—
	17, 18, 19	5.1-6.1	8-32	1-1	2-13	17-47	0.06-0.06	0.2-1.1	1.2-3.7	6.4-7.9	—
Bidens bidentoides	T	4.8	118	1	14	41	0.09	0.8	2.5	6.1	2
	6										
Boltonia asteroides	E	6.8	38	5	15	42	0.37	1.0	3.0	7.1	22
	31										
Carex bullata	E (3)	3.8±0.1	50±3	1±0	2±1	5±0	0.23±0.04	0.6±0.1	1.3±0.1	28.6±2.0	60±15
	3	3.7-3.9	46-52	1-1	1-3	4-5	0.20-0.28	0.4-0.7	1.2-1.5	25.9-30.8	41-78
Carex collinsii	E (3)	4.1±0.1	111±5	4±1	13±4	21±2	0.78±0.16	2.8±0.7	4.6±0.3	22.9±1.2	57±12
	43	4.0-4.3	106-117	3-4	9-17	19-23	0.60	2.1-3.6	4.2-4.9	21.3-24.0	41-69

Table 1 (cont'd)

Species	Sta[a] (*N*)[b] Loc[c]	pH	lbs/ac	%			meq/100g				% Org
			P	K	Mg	Ca	K	Mg	Ca	CEC	
Carex diandra	T (2)	5.4±0.2	261±33	10±1	20±1	59±3	2.50±0.10	3.1±2.5	39.7±4.3	25.5±1.4	90±3
	62, **64**	5.1-5.6	228-293	9-11	19-21	56-62	2.40-2.60	0.5-5.6	35.4-44.0	24.1-26.9	87-92
Carex eburnea	E (4)	7.0±0.1	16±8	1±0	12±1	87±0	0.21±0.03	1.8±0.2	14.3±1.5	16.1±1.4	25±6
	33	6.8-7.2	6-28	1-1	11-12	87-88	0.16-0.25	1.5-2.0	12.0-16.0	14.2-18.0	22-35
Carex flava	T (4)	7.0±0.5	31±7	1±1	36±7	60±10	0.22±0.07	9.6±4.0	27.0±13.8	25.4±6.8	41±21
	49, **50**, **51**	6.6-7.8	20-39	0-2	29-46	47-70	0.11-0.29	4.0-15.0	9.8-45.0	14.0-31.9	9-61
Carex oligosperma	T (10)	4.3±0.5	172±89	12±7	15±6	30±8	2.94±3.13	3.5±2.1	6.8±2.8	22.0±5.5	89±16
	41, 54, **55**, **57**, **59**, 60, 61	3.5-5.5	14-334	1-31	2-25	7-36	0.14-12.51	0.3-9.5	1.2-13.8	16.8-37.7	40-97
Carex pauciflora	E	4.0	135	5	10	49	1.40	2.9	14.0	8.3	94
	62										
Carex paupercula	T (6)	4.1±0.3	131±48	6±3	16±10	37±19	1.78±1.03	4.3±3.2	10.0±5.7	27.7±6.2	91±5
	39, **40**, **41**, **52**, 70	3.8-4.5	68-185	3-11	4-28	10-55	0.46-3.40	1.1-8.9	3.3-18.0	14.5-33.1	85-97
Carex polymorpha	E (14)	4.3±0.6	64±36	3±1	5±5	17±16	0.59±0.44	1.1±1.1	2.9±2.2	20.5±7.3	40±28
	34, **43**, **45**	3.6-5.7	22-122	1-6	2-17	4-53	0.10-1.50	0.2-3.6	0.7-6.7	12.5-33.7	8-90
Carex sterilis	T (6)	7.0±0.4	29±9	1±1	38±7	58±9	0.22±0.06	10.4±3.9	28.0±14.3	26.2±6.1	47±19
	49, **50**, **51**	6.6-7.8	14-39	0-2	29-46	47-70	0.11-0.29	4.0-15.0	9.8-45.0	14.0-31.9	9-64
Carex tetanica	T (5)	6.7-0.4	29±8	1±0	35±8	59±8	0.19±0.06	9.4±3.6	24.9±12.9	25.7±4.9	46±19
	48, **49**, **50** **51**	6.0-7.2	14-39	0-1	23-46	47-68	0.11-0.29	4.0-15.0	11.3-45.0	17.4-31.9	14-64
Cladium mariscoides	E (6)	4.8±0.9	170±162	8±5	14±6	43±8	1.44±1.23	2.4±1.9	6.1±3.7	14.2±7.4	63±43
	54, **64**, **70** **71**	3.8-6.0	14-476	2-14	7-23	31-54	0.10-2.80	0.3-5.4	2.0-13.0	4.4-23.2	3-97

Table 1 (cont'd)

Species	Sta[a] (*N*)[b] Loc[c]	pH	lbs/ac P	% K	 Mg	 Ca	meq/100g K	 Mg	 Ca	 CEC	% Org
Dodecatheon amethystinum	T 28	7.2	24	2	9	89	0.53	2.4	23.7	26.7	—
Dodecatheon meadia	E 26	4.9	63	3	8	64	0.55	0.8	10.2	16.2	18
Dryopoteris campyloptera	E (4) **68**, **69**	4.3±0.5 3.4-4.6	175±50 90-212	3±1 1-3	4±1 2-6	15±5 7-20	0.57±0.15 0.32-0.70	0.8±0.1 0.6-1.0	3.5±0.8 2.2-4.3	23.3±5.6 19.6-32.9	61±2 59-65
Echinochloa walteri	E **5**	6.9	143	2	25	73	0.10	1.2	3.5	4.8	2
Eleocharis obtusa var. *peasei*	E **6**	5.3	112	1	13	3.7	0.07	1.4	4.0	10.8	—
Eleocharis parvula	E (2) **6**	5.3±0.0 5.3-5.3	228±18 210-246	2±0 2-2	18±2 16-20	27±1 26-27	0.11±0.04 0.07-0.15	1.1±0.3 0.7-1.4	2.1±1.1 1.0-3.2	6.3±2.4 3.8-8.7	3±1 2-4
Elephantopus carolinianus	E **24**	4.9	24	2	7	24	0.21	1.0	3.3	13.4	11
Ellisia nyctelea	T **16**	6.9	164	3	20	78	0.42	3.3	13.0	16.7	21
Eriophorum viridicarnatum	T (5) **49**, **50**, 51	6.8±0.3 6.6-7.2	31±9 14-39	1±0 0-1	40±6 31-46	55±8 47-68	0.22±0.07 0.11-0.29	11.6±2.9 8.5-15.0	31.6±12.9 15.0-45.0	28.6±3.0 23.8-31.9	55±10 35-64
Euphorbia ipecacuanhae	E 12	4.2	160	1	12	29	0.21	2.0	5.0	17.4	17
Glyceria borealis	E **64**	4.5	81	1	2	30	0.15	0.4	5.0	16.9	19
Helianthemum bicknellii	E **37**	4.8	118	2	2	11	0.29	0.3	1.5	13.5	14

Table 1 (cont'd)

Species	Sta[a] (*N*)[b] Loc[c]	pH	lbs/ac P	% K	 Mg	 Ca	meq/100g K	 Mg	 Ca	 CEC	% Org
Ilex opaca	T (2) 30, 32	5.2±1.1 4.1-6.2	71±16 55-87	2±1 1-3	8±5 3-13	32±24 8-55	0.26±0.07 0.19-0.32	0.8±0.1 0.1-0.9	2.9±0.9 2.0-3.8	15.6±8.8 6.8-24.3	38±9 29-47
Juncus dichotomus	E (2) **3**	4.7±0.1 4.6-4.8	61±38 23-98	1±0 1-1	4±1 3-4	11±3 8-13	0.13±0.04 0.09-0.16	0.5±0.2 0.3-0.7	1.4±0.6 0.8-2.0	12.2±3.3 8.9-15.4	8±1 7-9
Juncus biflorus	E 13	4.6	29	2	8	20	0.10	0.6	1.5	7.5	14
Juncus militaris	E **53**	5.4	19	1	7	25	0.03	0.2	0.8	3.0	1
Juncus torreyi	T **58**	7.6	42	2	9	89	0.23	1.0	10.3	11.5	9
Lobelia dortmanna	T **71**	6.0	14	2	7	45	0.10	0.3	2.0	4.4	3
Lobelia kalmii	E (3) **49**, 50	7.0±0.6 6.6-7.8	30±8 20-39	1±0 1-2	38±7 29-46	57±10 47-70	0.25±0.03 0.23-0.29	10.0±4.5 4.0-15.0	29.9±14.8 98.0-45.0	24.7±7.7 14.0-31.9	42±24 9-61
Lyonia mariana	E (3) **20, 23**	4.6±0.7 3.9-5.6	26±12 13-46	2±2 0-6	6±4 2-11	15±10 4-30	0.50±0.52 0.07-1.40	0.7±0.3 0.4-1.0	1.8±0.7 0.8-2.5	17.4±8.8 5.0-29.5	16±8 4-27
Magnolia tripetala	T (3) 3, **4**	4.3±0.5 4.0-5.0	37±15 16-51	1±0 0-1	3±1 2-5	8±7 3-17	0.10±0.02 0.07-0.12	0.6±0.3 0.4-1.0	1.5±1.0 0.8-3.0	21.8±2.7 18.0-23.8	34±7 26-42
Magnolia virginiana	T (8) 3	4.0±0.4 3.3-4.9	17±13 6-52	1±0 0-1	2±2 1-7	7±6 1-18	0.13±0.06 0.06-0.25	0.5±0.3 0.1-1.1	1.0±0.7 0.2-2.8	20.6±8.1 8.4-31.7	47±31 50-90
Montia chamissoi	E **63**	7.1	61	3	11	46	0.10	0.6	2.5	5.4	—
Muhlenbergia uniflora	E **44**	4.7	13	1	1	3	0.12	0.2	0.5	14.7	10

Table 1 (cont'd)

Species	Sta^a (*N*)^b Loc^c	pH	lbs/ac P	% K	 Mg	 Ca	meq/100g K	 Mg	 Ca	 CEC	% Org
Myrica gale	T (2) **45**	4.2±0.3 3.9-4.5	107±45 62-151	4±3 1-7	11±9 2-20	34±22 12-55	1.12±0.68 0.44-1.80	2.9±2.3 0.6-5.2	10.9±7.2 3.7-18.0	29.1±1.7 27.4-30.8	84±10 74-93
Myriophyllum tenellum	T **71**	6.0	14	2	7	45	0.10	0.3	2.0	4.4	3
Panicum xanthophysum	E 37	4.2	83	1	1	5	0.17	0.2	0.8	16.1	30
Parnassia glauca	E (3) **49**, **50**, 51	7.0±0.4 6.6-7.8	29±9 14-39	1±1 0-2	38±7 29-46	58±9 47-70	0.22±0.06 0.11-0.29	10.4±3.9 4.0-15.0	28.0±14.3 9.8-45.0	26.2±6.1 14.0-31.9	47±19 9-64
Poa paludigena	T 1	4.6	109	1	10	27	0.30	2.0	5.5	20.4	25
Polemonium van-bruntiae	E (2) **67**	5.7±0.0 5.7-5.7	15±3 12-18	0 0-0	6±1 5-6	71±2 69-72	0.14±0.02 0.11-0.16	1.8±0.2 1.6-1.9	23.0±1.0 22.0-24.0	32.6±1.3 31.3-33.8	86±0 86-86
Polygala curtissii	E 21	4.9	6	1	20	17	0.05	0.1	0.8	4.3	4
Polygonum robustius	T (3) 11	5.3±0.3 4.9-5.6	65±17 42-83	2±0 2-2	16±5 11-23	42±8 33-53	0.20±0 0.20-0.21	1.7±0.4 1.3-2.2	4.3±0.5 4.0-5.0	10.4±1.1 9.4-12.0	44±22 18-72
Polystichum braunii	E (8) 35, **56**, 66, **72**	4.8±0.3 4.5-5.2	174±103 38-316	2±1 1-4	6±1 5-8	33±12 18-54	0.62±0.19 0.32-0.90	1.5±0.3 1.0-2.0	9.0±4.6 3.4-17.0	26.6±4.6 21.0-34.3	56±16 21-71
Potentilla tridentata	E 36	3.9	44	1	1	3	0.11	0.2	0.5	15.8	17
Ptelea trifoliata	T **15**	6.7	57	2	14	73	0.43	2.6	14.0	18.8	16

Table 1 (cont'd)

	Sta[a] (*N*)[b]		lbs/ac	%			meq/100g				
Species	Loc[c]	pH	P	K	Mg	Ca	K	Mg	Ca	CEC	% Org
Quercus falcata	E 7	4.1	67	2	3	9	0.46	0.8	2.3	24.7	27
Quercus phellos	E (10) 3, 4, 7	4.1±0.3 3.7-4.8	33±29 8-98	1±1 0-2	2±1 1-4	5±4 1-13	0.15±0.11 0.07-0.46	0.5±0.1 0.3-0.8	1.1±0.8 0.3-2.5	22.1±6.1 8.9-32.9	39±20 7-64
Rhexia mariana	E (5) 3, 8	4.9±0.4 4.2-5.3	46±43 23-142	3±1 1-4	6±3 2-9	17±12 3-31	0.24±0.08 0.09-0.30	0.6±0.2 0.3-0.7	1.6±0.9 0.5-2.6	11.2±4.0 7.2-18.7	12±4 7-17
Rhynchospora capillacea	E (3) **49**, 50	7.0±0.6 6.6-7.8	30±8 20-39	1±0 1-2	38±7 29-46	57±10 47-70	0.25±0.03 0.23-0.29	10.0±4.5 4.0-15.0	29.9±14.8 9.8-45.0	24.7±7.7 14.0-31.9	42±24 9-61
Sagittaria calycina	E (2) 2, 9	5.6±0.1 5.5-5.6	178±50 128-228	2±0 2-2	17±2 15-19	38±2 36-40	0.20±0.04 0.16-0.24	1.6±0.4 1.2-2.0	3.6±0.6 3.0-4.2	9.5±1.1 8.3-10.6	5±1 4-5
Schoenoplectus smithii	E 6	5.7	178	2	17	30	0.14	1.2	2.2	7.5	4
Scleria pauciflora	T (4) **21**, 25	6.5±0.5 6.0-7.0	9±2 6-12	1±0 1-1	80±4 76-86	12±2 10-16	0.17±0.03 0.14-0.20	14±1.7 11-15	2.1±0.1 2.0-2.3	17.2±2.7 12.7-19.4	11±2 8-13
Scleria verticillata	E (3) **49**, 50	7.0±0.6 6.6-7.8	30±8 20-39	1±0 1-2	38±7 29-46	57±10 4.7-70	0.25±0.03 0.23-0.29	10±4.5 4-15	29.9-14.8 9.8-45.0	24.7-7.7 14.0-31.9	42-24 9-61
Sedum rosea	E (3) **14**	5.5±0 5.5-5.5	52±4 49-58	2±0 2-2	15±1 13-16	55±3 51-59	0.39±0 0.38-0.39	2.6±0.1 2.5-2.7	10.6±0.4 10.0-11.0	18.7±0.7 17.7-19.5	29±2 27-31
Sisyrinchium atlanticum	E (4) **3**, 8, **9**, **10**	4.7±0.2 4.5-4.9	99±124 8-313	2±1 1-3	3±1 2-5	7±5 2-15	0.23±0.12 0.12-0.42	0.5±0.2 0.3-0.8	1.0±0.8 0.2-2.3	15.2±0.6 14.7-16.3	11±4 6-15
Solidago simplex ssp. *randii* var. *racemosa*	E 73	5.7	27.00	3	11	32	0.20	0.9	2.5	7.7	12

Table 1 (cont'd)

Species	Sta[a] (*N*)[b] Loc[c]	pH	lbs/ac P	% K	 Mg	 Ca	meq/100g K	 Mg	 Ca	 CEC	% Org
Utricularia intermedia	T (2)	5.5±0.1	153±75	9±3	19±0	63±1	2.00±0.60	2.4±1.9	37.2±1.8	23.8±0.3	87±6
	62	5.4-5.6	78-228	6-11	19-19	62-64	1.40-2.60	0.5-4.3	35.4-39.0	23.4-24.1	81-92
Vernonia glauca	E	6.5	219	5	18	56	0.48	1.7	5.3	9.4	10
	46										
Viburnum nudum	E (5)	4.1±0.4	10±2	1±0	3±2	5±7	0.11±0.01	0.5±0.3	0.9±0.9	21.5±3.5	60±4
	3	3.8-4.9	8-13	0-1	1-7	1-18	0.10-0.12	0.4-1.1	0.3-2.8	15.4-26.0	55-64
Viola pedatifida	E (2)	4.25±0.1	38±16	1±0	3±0	5±4	0.24±0.09	0.75±0.05	1.1±0.9	23.9±2.4	24±3
ssp. *brittoniana*	3	4.2-4.3	22-53	1-1	3-3	1-9	0.15-0.32	0.7-0.8	0.2-2	21.5-26.2	21-26

[a] Sta = plant's status in Pennsylvania: E—endangered, T—threatened, X—extirpated.

[b] (*N*) = number in parentheses is number of soil samples (no number means there was only one sample).

[c] Loc = number is plant location given in Table 2. The bold numbers indicate a voucher specimen is at the Morris Arboretum.

Table 2. Plant locations corresponding with location numbers in Table 1.

- PENNSYLVANIA
  - Berks Co: Union Twp (1).
  - Bucks Co: Bensalem Twp (2), Bristol Twp (3-8), Bristol Boro (9, 10), Bristol Twp (11), Falls Twp (12), Lower Makefield Twp (13), Nockamixon Twp (14), Solebury Twp (15), Upper Makefield Twp (16).
  - Chester Co: Coatesville Boro (20), Elk Twp (21, 22), West Whiteland Twp (23).
  - Delaware Co: Haverford Twp (24), Middletown Twp (25).
  - Franklin Co: Montgomery Twp (26, 27).
  - Lancaster Co: E. Hempfield Twp (28), Hemfield Twp (29), Drumore Twp (30), Martic Twp (31, 32).
  - Lehigh Co: North Whitehall Twp (33).
  - Luzerne Co: Dennison Twp (34), Fairmount Twp (35), Fairview Twp (36), Pittston Twp (37).
  - Monroe Co: Coolbaugh Twp (38, 39), Tobyhanna Twp (40-42), Tunkhannock Twp (43-45).
  - Montgomery Co: Lower Providence Twp (46), Upper Hanover Twp (47).
  - Northampton Co: Hellertown Boro (48), Upper Mt Bethel (49-51).
  - Pike Co: Porter Twp (52, 53).
  - Sullivan Co: Colley Twp (54, 55), Davidson Twp (56), Laporte Twp (57).
  - Tioga Co: Charleston Twp (58), Chatham Twp (59), Shippen Twp (60, 61).
  - Wayne Co: Buckingham Twp (62), Manchester Twp (63), Mt Pleasant Twp (64), Preston Twp (65-70), Scott Twp (71, 72), Sterling Twp (72).
  - York Co: Lower Chanceford (73).
- NEW JERSEY
  - Burlington Co: Woodland Twp (17, 18), Southampton Twp (19).

Bartonia No. 59: 107-111, 1996

Soil Chemical and Physical Properties Associated with Two Pennsylvania Threatened Plant Species (*Juncus biflorus* and *Aster dumosus*) at Crow's Nest Farm, Chester County

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The grass rush (*Juncus biflorus* Ell.) and the bushy aster (*Aster dumosus* L.) have been proposed for listing under Title 25, Chapter 82 of the Pennsylvania Wild Plant Conservation Act (Rhoads & Klein 1993). The Vascular Plant Technical Committee of the Pennsylvania Biological Survey has recommended threatened status for *J. biflorus*, while the status of *A. dumosus* remains undetermined (E. Dix, Pennsylvania Natural Diversity Inventory, pers. comm.). *Juncus biflorus*, a facultative wetland species (sensu Reed 1988), commonly is found in moist or wet areas within meadows and shores; *Aster dumosus*, a facultative upland species (sensu Reed 1988), generally is found in dry or moist, and often sandy areas, near or on the coastal plain (Gleason & Cronquist 1991). Both species occur in a small meadow (about 0.5 ha) surrounded by successional deciduous forest at the Crow's Nest Farm site, Chester County, PA. Red maple (*Acer rubrum*) and tulip poplar (*Liriodendron tulipifera*) may be encroaching upon the meadow. Invasion of the meadow by woody vegetation would likely alter local environmental conditions, which in turn may lead to decline or local elimination of *J. biflorus* and *A. dumosus*. As a first step toward developing a management plan for maintaining these two threatened species, this study was undertaken to characterize surface soil chemical and physical properties in the meadow and in the surrounding forest. Results have relevance to the broader question: are the environmental conditions at the Crow's Nest Farm site suitable for continued survival of *J. biflorus* and *Aster dumosus*?

STUDY SITE

The section of Crow's Nest Farm that was studied consists of a meadow, 0.5 ha, surrounded by mixed deciduous forest, containing red maple (*Acer rubrum*) and tulip poplar (*Liriodendron tulipifera*). The soil was classified as a Croton silt loam, characterized by poor drainage on uplands, with 3 to 8% slopes (USDA 1963). However, in northern Chester County, where our study site is located, soils tend to be shallower over bedrock, allowing for better surface drainage than soils characteristic of the Croton series. Surface soils for this series generally consist of a dark-brown silt loam layer, with a subsoil layer of yellowish-brown and reddish-brown silty clay loam. A claypan 38-56 cm below the surface tends to slow internal drainage. Croton silt loam soils promote the growth of black oak, red oak, cottonwood, maple, ash, hickory, and elm comprising hardwood forests.

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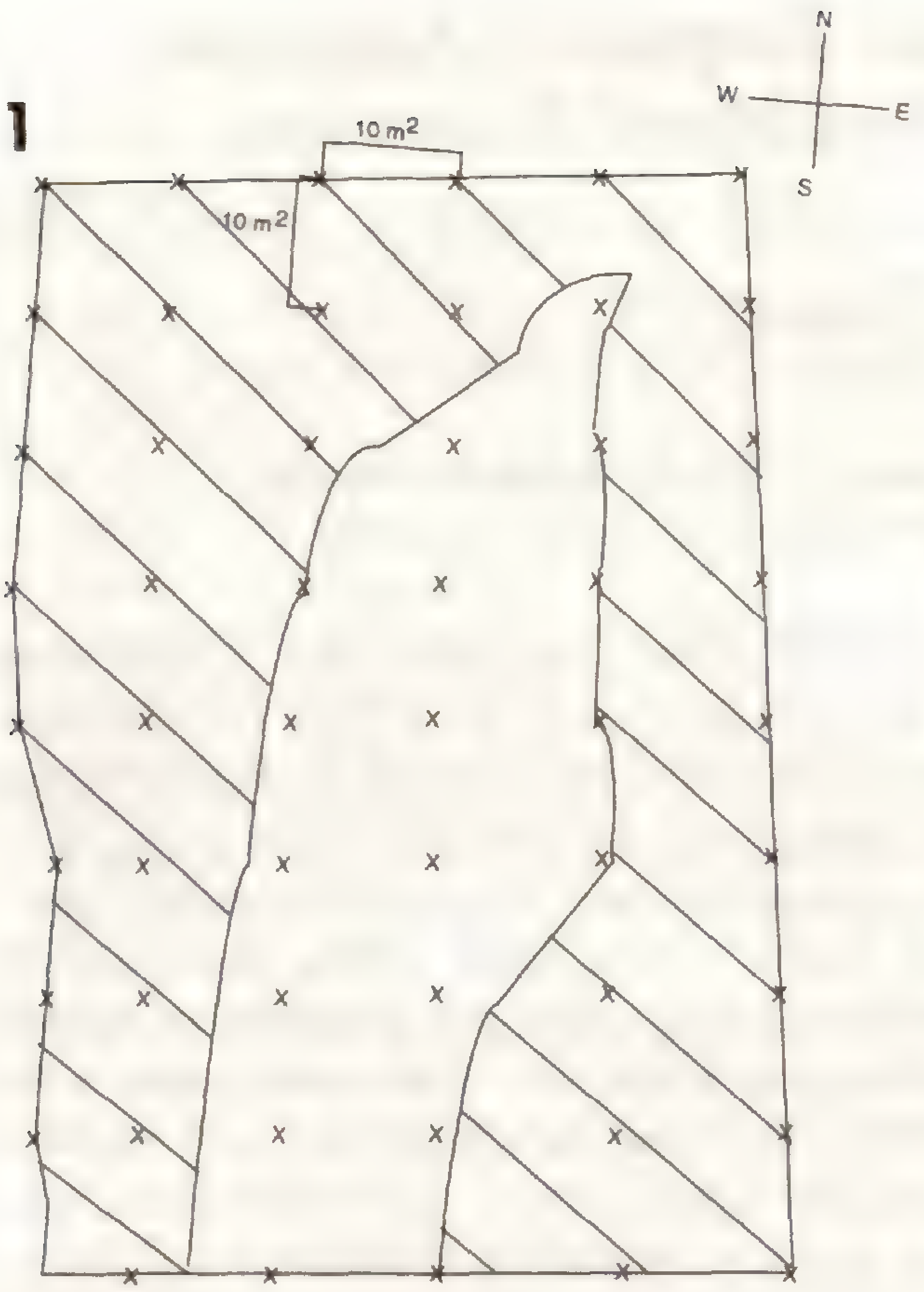
1



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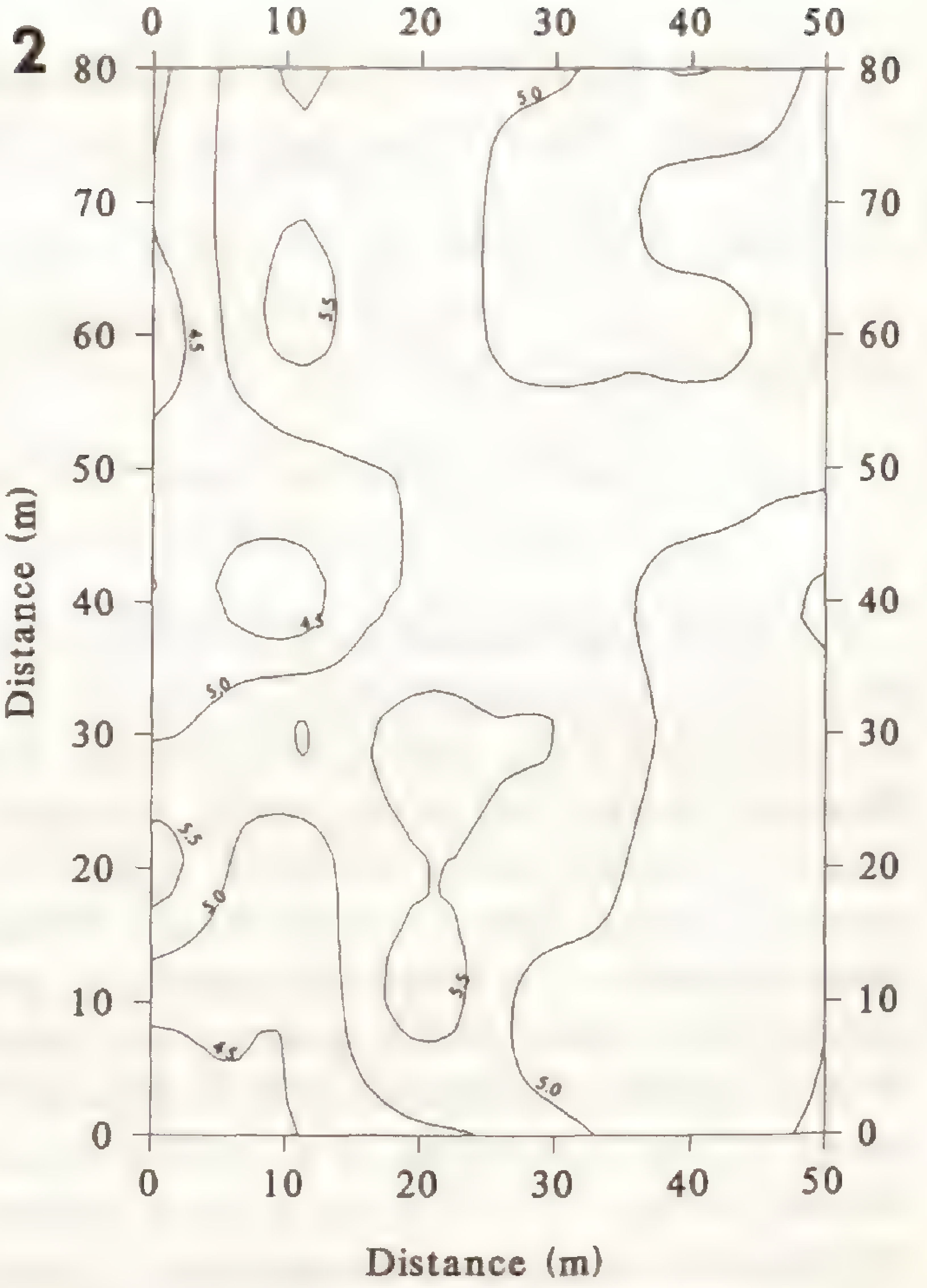

Figs. 1 & 2. Fig. 1, Sampling grid showing meadow (unshaded area) surrounded by forest (shaded area). Fig. 2, Contour plot of pH, one of the three variables that separated the forest from the meadow in the multivariate stepwise discriminant analysis. The plot was generated using negative exponential smoothing, using the 53 grid point measurements of soil pH; contour interval is 0.5 pH units (SYSTAT 1993).

METHODS

A sampling grid was established in the meadow and adjacent forested area (Fig. 1). At each of the 53 grid nodes, we collected two soil samples (10 cm deep, 5 cm diameter) using an AMS soil core sampler with hammer attachment. For one soil sample from each location, soil wet weight was recorded before oven-drying the sample for one week at 60° C; bulk density and water content were then calculated. The dried soil samples were sieved through a 2 mm mesh screen prior to determining percentages of sand, silt and clay using the hydrometer method (Day 1965). Sand was defined as particles ranging from 50 μm to 2 mm in diameter, silt as particles ranging from 2 to 50 μm, and clay as particles smaller than 2 μm. For the second soil sample from each location, a subsample was analyzed immediately for pH (1:1 soil/water slurry). Within 24 hr of soil collection, separate soil subsamples were extracted with dilute acid-fluoride (Bray's P; Olsen & Sommers 1982) and 10 mM $CaCl_2$ (Adams 1974). The dilute acid-fluoride extracts were analyzed for PO_4^{3-}-P colorimetrically (stannous chloride method). The $CaCl_2$ extracts were analyzed for SO_4^{2-}-S and NO_3^--N by ion chromatography and for NH_4^+-N using the colorimetric phenate method. Soil water contents and bulk densities were used to convert chemical concentrations determined for fresh soils to a per gram dry mass or cm^{-3} basis.

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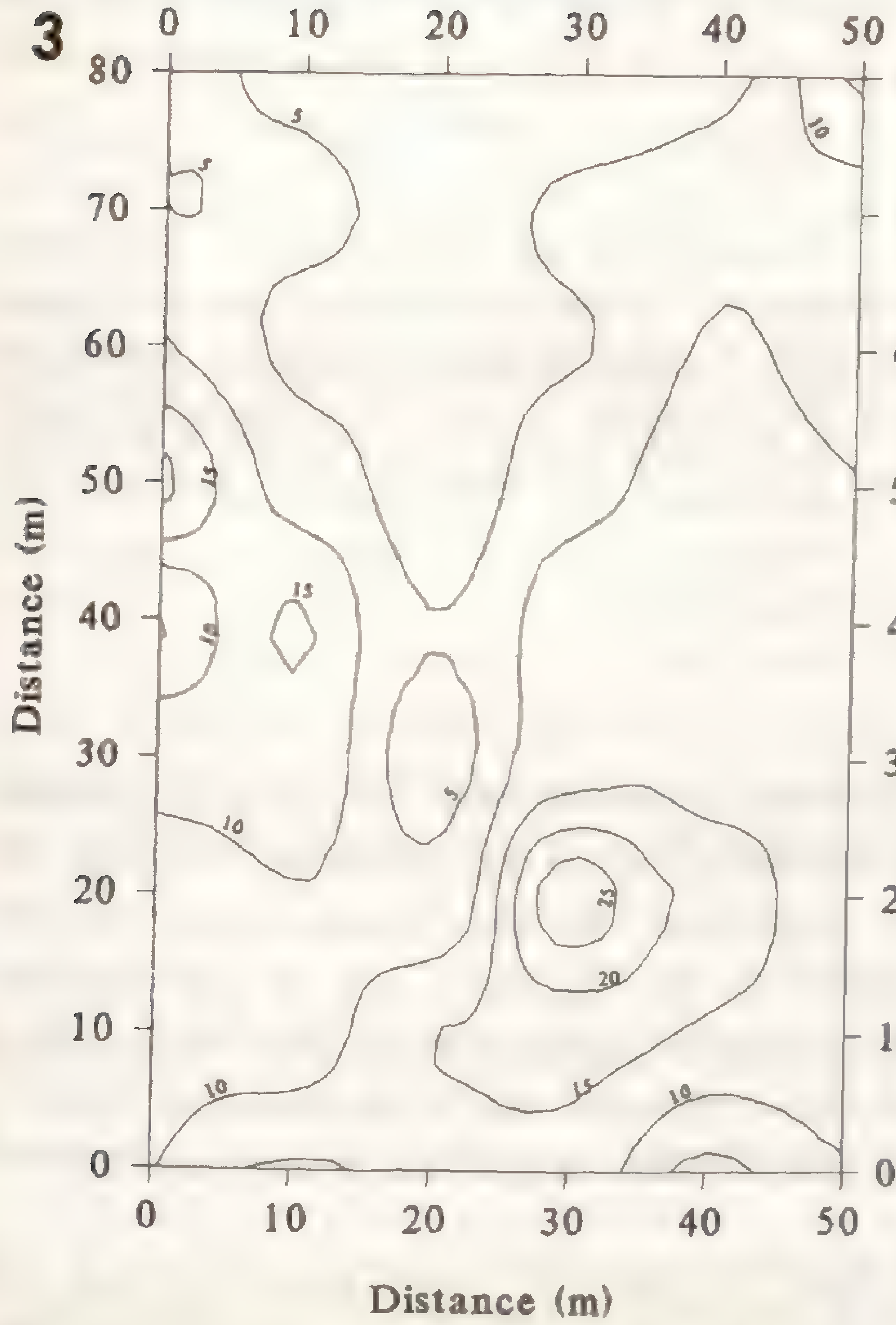

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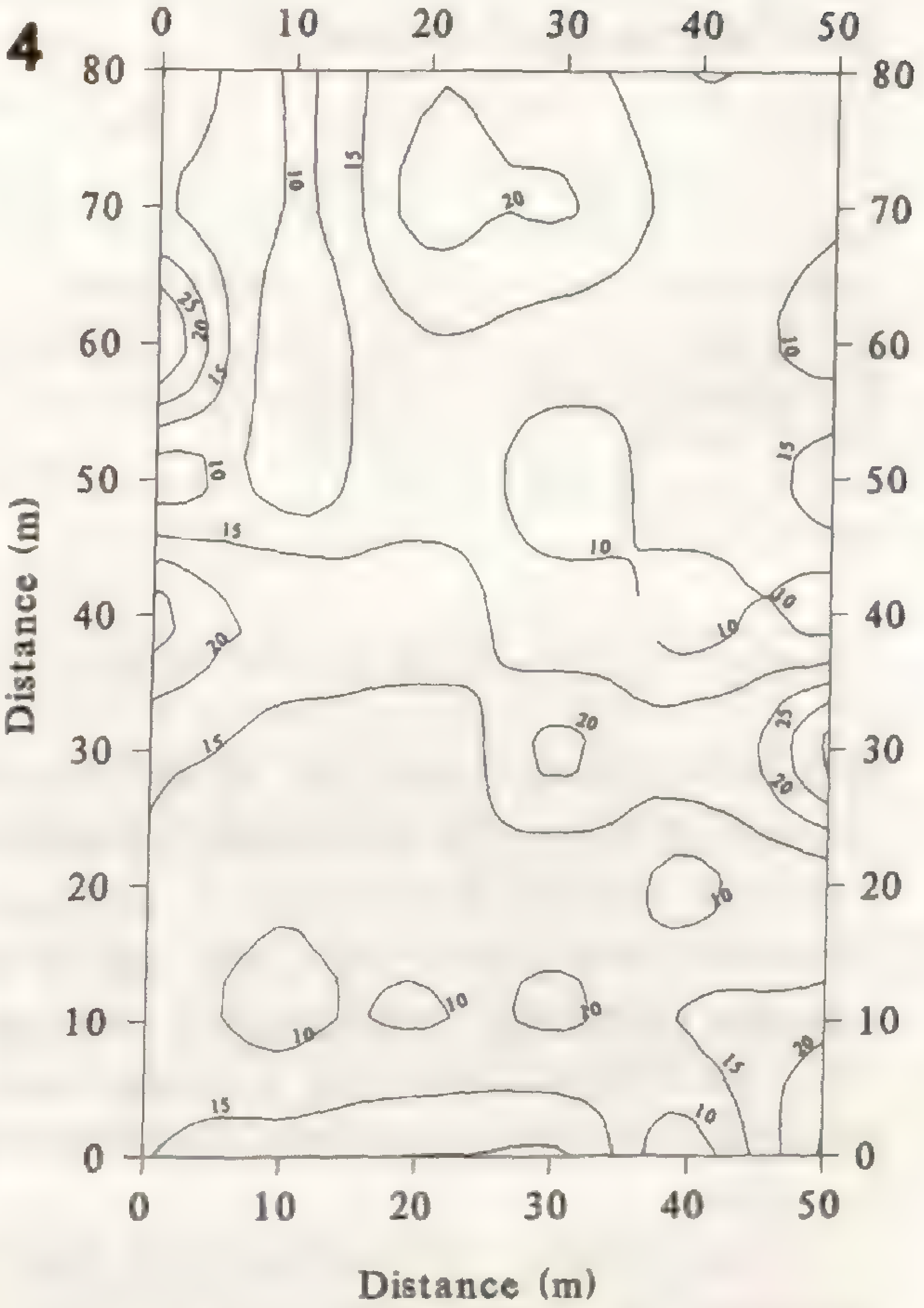

Figs. 3 & 4. Fig. 3, Contour plot of available inorganic N (μg/cm^3), one of the three variables that separated the forest from the meadow in the multivariate stepwise discriminant analysis. The plot was generated using negative exponential smoothing, using the 53 grid point measurements of available soil inorganic N; contour interval is 5 μg N/cm^3 (SYSTAT 1993). Fig. 4, Contour plot of Bray's P (μg/cm^3), one of the three variables that separated the forest from the meadow in the multivariate stepwise discriminant analysis. The plot was generated using negative exponential smoothing, using the 53 grid point measurements of soil P; contour interval is 5 μg P/cm^3 (SYSTAT 1993).

RESULTS

The meadow soils and forest soils did not differ with regard to any of the physical variables and differed with regard to only one of the chemical variables, soil pH, which was higher in the meadow than in the forest (Table 1). A multivariate stepwise discriminant analysis (SAS 1990), using all soil chemical and soil physical variables, distinguished the forest and meadow areas of the study site on the basis of soil pH ($R^2 = 0.1219$; $p = 0.0104$), total $CaCl_2$-extractable inorganic N (NO_3^--N + NH_4^+-N) concentrations (μg cm^{-3}; $R^2 = 0.0981$; $p = 0.0238$), and Bray's P concentrations (μg cm^{-3}; $R^2 = 0.0430$; $p = 0.1442$). Contour plots (Figs. 2-4) reveal spatial variability in these three soil variables within the study site. These plots further substantiate a general pattern of higher soil pH, lower available inorganic N, and lower Bray's P in the meadow than in the forest (cf. Fig. 1).

DISCUSSION

Juncus biflorus and *Aster dumosus*, although broadly distributed throughout the eastern United States, have been proposed for listing under Title 25, Chapter 82 of the Pennsylvania

Table 1. Summary information for forest and meadow at Crow's Nest Farm (values represent mean ± std. error; N= 34 for forest, N = 19 for meadow).

Variable	Forest	Meadow	Variable	Forest	Meadow
Soil pH	4.9 ± 0.1*	5.1 ± 0.1	Bray's P (μg/g dry soil)	16.3 ± 1.7	12.9 ± 0.9
H_2O (% w/w)	27.5 ± 1.1	29.3 ± 0.8	Bray's P (μg/cm^3)	17.1 ± 1.8	13.3 ± 1.0
H_2O (g/cm^3)	0.39 ± 0.01	0.43 ± 0.01	SO_4^{2-}-S (μg/g dry soil)	8.9 ± 1.3	11.7 ± 2.1
NH_4^+-N (μg/g dry soil)	7.6 ± 0.9	9.5 ± 1.2	SO_4^{2-}-S (μg/cm^3)	9.5 ± 1.4	12.9 ± 2.6
NH_4^+-N (μg/cm^3)	7.6 ± 0.8	10.0 ± 1.3	Bulk density (g/cm^3)	1.05 ± 0.03	1.05 ± 0.04
NO_3^--N (μg/g dry soil)	0.9 ± 0.2	1.2 ± 0.3	Sand (%)	56.4 ± 1.6	55.3 ± 1.2
NO_3^--N (μg/cm^3)	0.9 ± 0.2	1.3 ± 0.4	Silt (%)	38.5 ± 1.3	39.8 ± 1.0
			Clay (%)	5.2 ± 0.6	4.9 ± 0.8

*Statistically significant at the 5% level; student's t-test.

Wild Plant Conservation Act. At the Crow's Nest Farm study site, the *J. biflorus* population consists of at least 50 individuals, mostly in the northern half of the meadow. Though not positively identified in 1994, *A. dumosus* was confirmed by the Pennsylvania Natural Diversity Inventory a few years ago to be located at the southern end of the meadow (Stevens Heckscher, pers. comm.). Neither species occurs in the surrounding forest. As a first step toward developing a management plan for *J. biflorus* and *A. dumosus* at Crow's Nest Farm, this study compared soil chemical and soil physical properties in the meadow and the forest.

Reconnaissance of the field site suggested that the meadow area may represent an abandoned farm road connecting the public road just to the south of the meadow with a field just to the north. Therefore, we expected to see a greater soil bulk density in the meadow than in the forest resulting from compaction of the surface soils along the farm road. If the meadow is indeed an abandoned farm meadow, this past disturbance is not reflected in any of the soil physical properties at the site today.

Both meadow and forest soils contained about 56% sand, 39% silt, and 5% clay, classifying the soils as sandy loams. Although we found no information on edaphic tolerances for *A. dumosus*, the preference for sandy soils appears to be indicative of other related species of aster. Abrahamson & Solbrig (1970) reported that *A. cordifolius*, *A. undulatus*, and *A. lowreianus* preferred soils that had a high sand percentage with a favored range in soil pH of 5.5 to 6.8.

Meadow soils differed from the forest soils in terms of chemical properties. The lower soil pH in the forest than in the meadow is likely the result of the decomposition of the forest leaf litter. The lower available inorganic N and Bray's P in the meadow than in the forest may indicate less favorable conditions for tree growth in the meadow. However, both red maple and tulip poplar, abundant in the surrounding forest, are notoriously good colonizers of open sites (Harlow et al. 1979). Their encroachment upon the meadow should be monitored. Tree invasion of the meadow is a possible threat to the persistence of *J. biflorus* and *A. dumosus*. However, a potentially greater threat to *J. biflorus* and *A. dumosus* is the presence of Japanese stilt-grass (*Microstegium vimineum* (Trin.) A. Camus). This non-native aggressive, invasive species has been expanding its range in Pennsylvania in recent years (Rhoads & Klein 1993). *Microstegium* is widely dispersed throughout the meadow and has the potential, if left unmonitored, to outcompete and exclude *J. biflorus* and *A. dumosus*.

The persistence of *J. biflorus* and *A. dumosus* at this site will depend on the complex interactions of a wide variety of abiotic and biotic factors that influence plant success. The descriptive nature of this study precludes definitive conclusions about the role of soil chemical properties in affecting these two plant species. However, it appears that *Aster dumosus* might be living at the lower end of its sand and pH tolerance. Therefore, encroachment by the surrounding forest should be closely monitored to assess its possible impact on soil physical properties and pH. In addition, the population of Japanese stilt grass should be monitored because of its potential to exclude both *J. biflorus* and *A. dumosus*. Therefore, competition with Japanese stilt-grass and tree invasion of the meadow appear to represent potentially serious short-term and long-term threats, respectively, to the persistence of *J. biflorus* and *A. dumosus* at Crow's Nest Farm.

ACKNOWLEDGMENTS

We thank Dr. Stevens Heckscher, Taylor Memorial Arboretum, Natural Lands Trust, for introducing us to the Crow's Nest Farm site and for providing useful information throughout the study. Mr. Scott Starr contributed valuable assistance in the field and laboratory.

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Bartonia No. 59: 113-117, 1996

Polypodium appalachianum, *P. virginianum*, and Their Hybrid in New Jersey and Pennsylvania

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In the early 1950s, Irene Manton and her co-workers discovered that the common eastern *Polypodium virginianum* L., or rock-cap fern, included both diploid (n=37) and tetraploid (n=74) races (Manton 1950, Manton & Shivas 1953). Evans (1970) reported that triploid hybrids also existed which had aborted spores and morphology intermediate between the diploid and tetraploid. The morphological differences between the diploid and tetraploid were summarized by Kott & Britton (1982). Haufler and co-workers (Haufler & Windham 1991, Haufler et al. 1995) determined that the tetraploid originated as a hybrid between the eastern diploid and a far northern species *P. sibericum* Siplivinskij, established that *P. virginianum* L. was the correct name for the tetraploid, and named the eastern diploid *P. appalachianum* Haufler and Windham.

New Jersey Ferns and Fern Allies (Montgomery & Fairbrothers 1992) and *The Vascular Flora of Pennsylvania, Annotated Checklist and Atlas* (Rhoads & Klein 1993) were published while work on this group was in progress. In both works the authors indicated that two species and a hybrid were included, but did not attempt to describe or map the geographic distribution of the species and hybrid.

The purpose of this paper is to present maps of the geographic distribution and discuss information on the habitats of *Polypodium appalachianum*, *P. virginianum*, and their hybrid (which does not have a binomial) in New Jersey and Pennsylvania.

METHODS

Herbarium specimens were examined for New Jersey and Pennsylvania from the following herbaria: BUPL, CHRB, CM, NY, PH (including PENN), US, YUO, and the author's personal herbarium. The specimens were identified using the characteristics listed by Kott & Britton (1982), Haufler & Windham (1991), and Haufler et al. 1993). As indicated by these authors, the most reliable characteristic to distinguish the diploid *P. appalachianum* from the tetraploid *P. virginianum* is the number of sporangiasters (modified sporangia) in the sorus (>40/sorus in *P. appalachianum*; < 40/sorus in *P. virginianum*). This characteristic is useful in the field and in most herbarium specimens collected in the late summer (when the spores mature) through early winter. Material collected in the spring and early summer usually has the sorus too disintegrated or too immature, and the relative number of sporangiasters cannot be determined. Blade shape (deltate and broadest near the base in *P. appalachianum*, narrowly elliptic and broadest near the middle in *P. virginianum*), and shape of the tips of the blade segments (acute or pointed in *P. appalachianum*, rounded in *P. virginianum*) are useful characteristics in herbarium specimens and in the field. Spore size was used in the laboratory to confirm identification of herbarium material. The hybrid can only be distinguished with certainty by its aborted spores. Many hybrid specimens can be identified tentatively by their intermediate morphology: the blade is rather straight-sided below the tapering apex with many segments nearly equal in length, and some of the segment tips are pointed. As Kott & Britton (1982) pointed out, removal of these hybrid specimens makes distinguishing the species much less difficult.

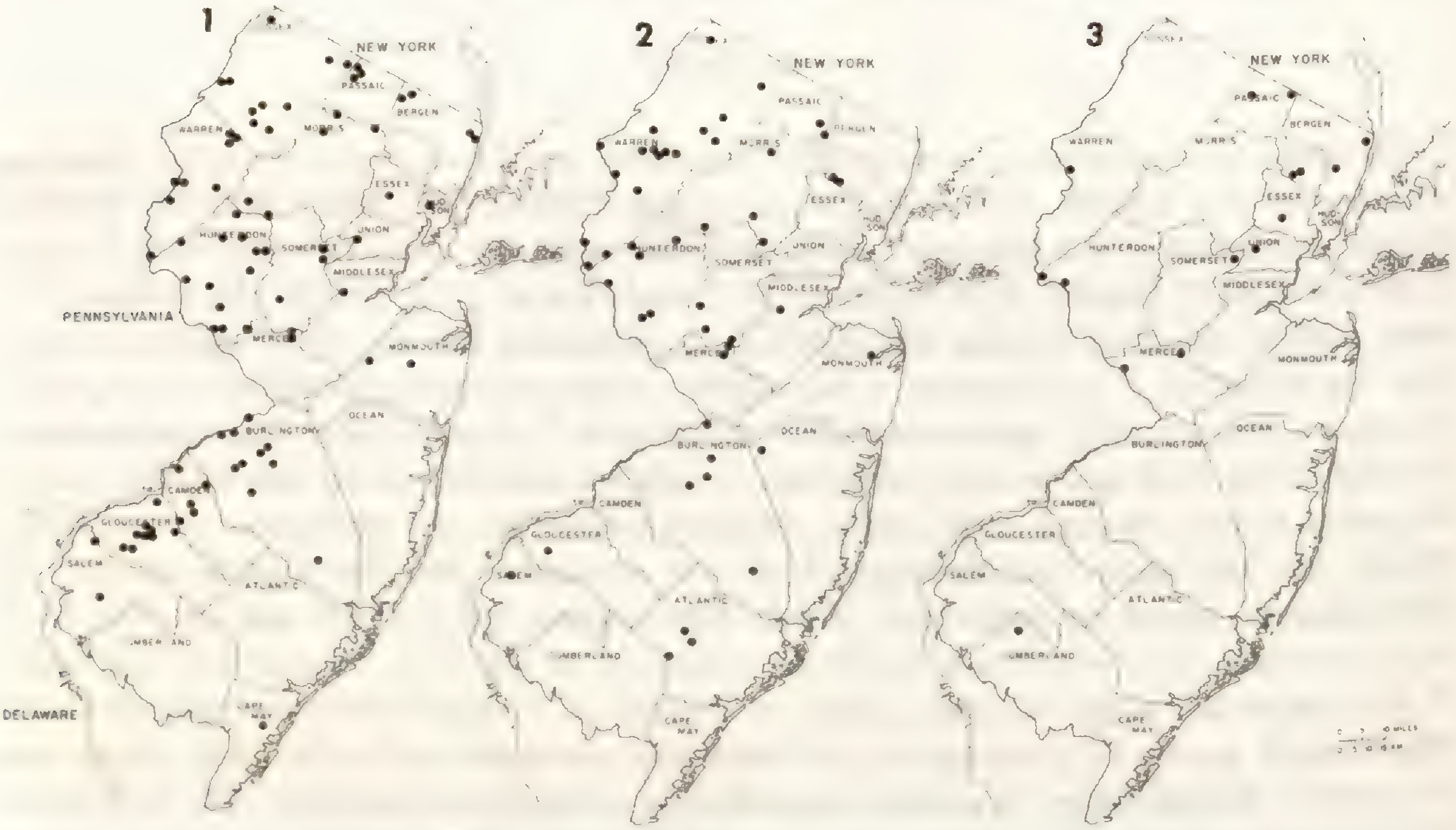
Maps of the distribution were prepared using base maps from Montgomery & Fairbrothers (1992) for New Jersey, and Rhoads & Klein (1993) for Pennsylvania. It was anticipated that some difference might be found in the habitat preference for the two species; therefore, habitat data were tabulated from those specimens that contained this type of information.

RESULTS AND DISCUSSION

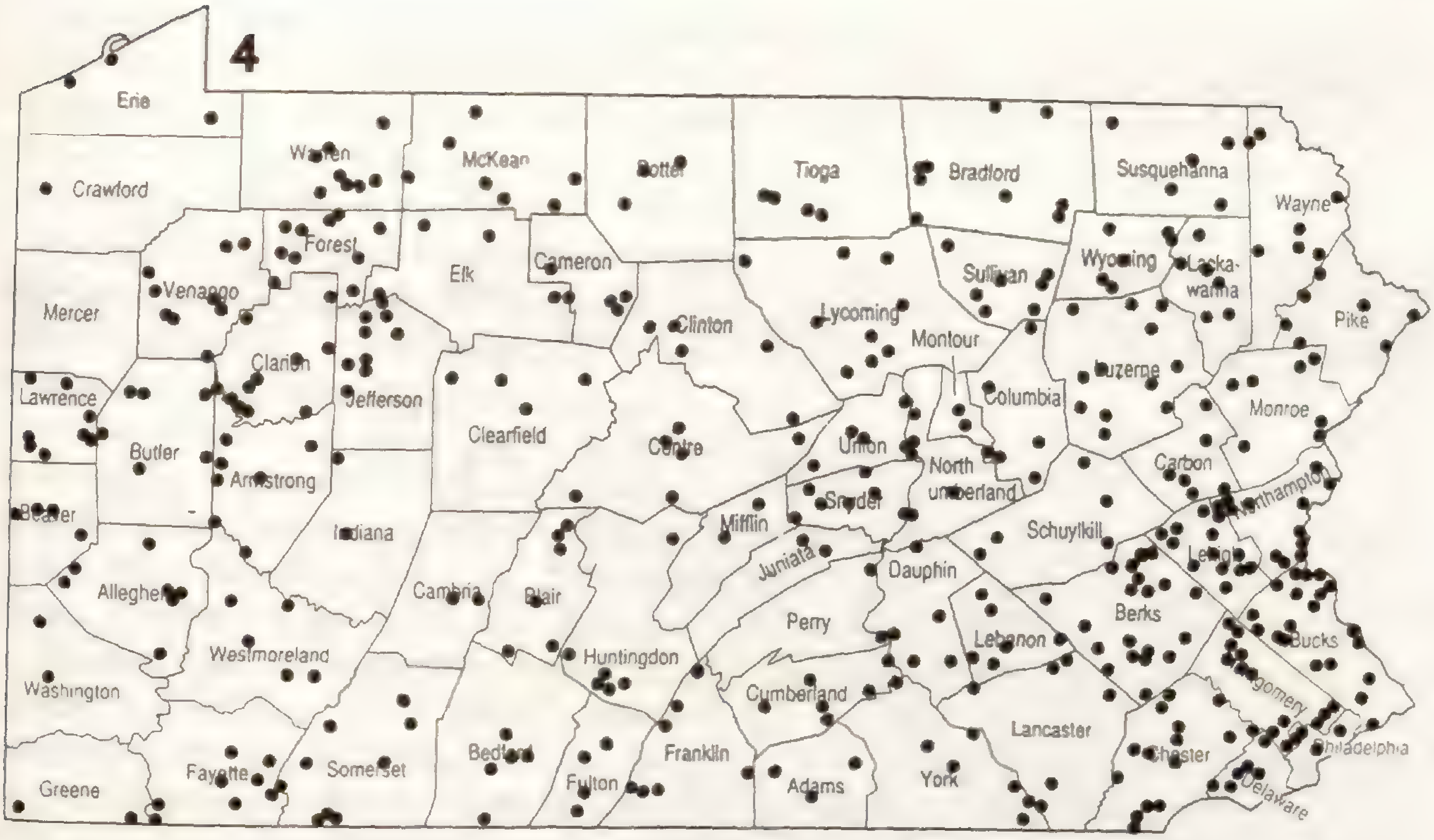
Somewhat less than 60% of the specimens from the two states represent *P. appalachianum*. In New Jersey, 54% are *P. appalachianum*, 35% *P. virginianum*, and 10% *P. appalachianum* × *virginianum*. In Pennsylvania, 59% are *P. appalachianum*, 31% *P. virginianum*, and 10% the hybrid. Assuming the species and hybrid have been collected in proportion to their occurrance, which seems reasonable given their morphological similarity, these numbers represent their relative abundance in New Jersey and Pennsylvania.

P. appalachianum has been recorded from 18 of New Jersey's 21 counties (Fig. 1). It is common in the northern part of the state and on the Inner Coastal Plain, but nearly absent from the Outer Coastal Plain. There is a single record from the Pinelands, from an old well.

P. virginianum has been recorded from 14 counties (Fig. 2). It is unrecorded from the urban counties of the northeast and much less common than *P. appalachianum* on the Inner Coastal Plain. There are four records from the Pinelands. Most of the records are from the Ridge and Valley and Highlands in the northwestern part of the state.



Figs. 1-3. Distribution of *Polypodium* in New Jersey. Fig. 1, *P. appalachianum*. Fig. 2, *P. virginianum*. Fig. 3, *P. appalachianum* × *virginianum*. Base map from Montgomery & Fairborthers (1992).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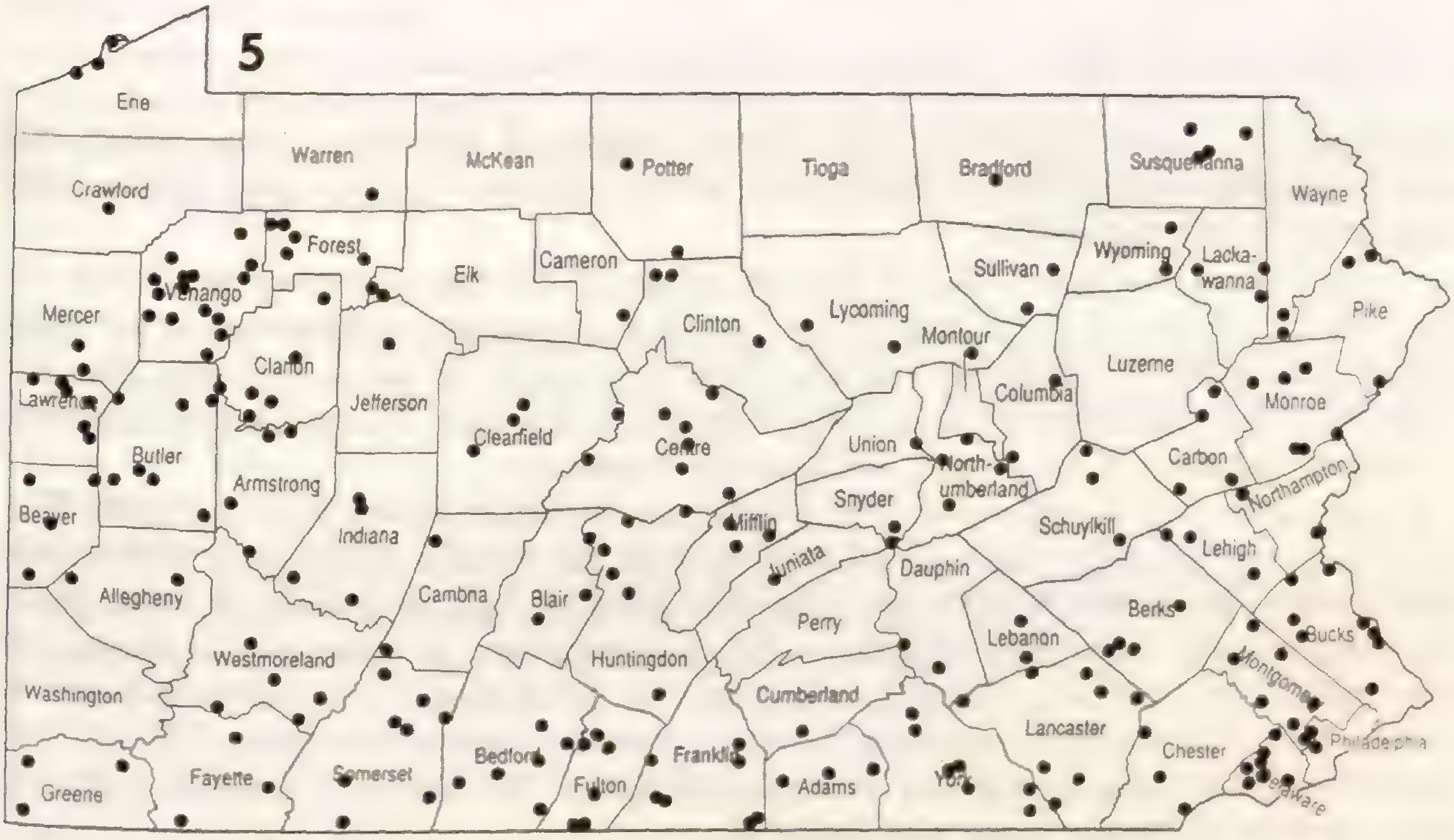
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Figs. 4 & 5. Distribution of *Polypodium* in Pennsylvania. Fig. 4, *P. appalachianum*. Fig. 5, *P. virginianum*. Base map from Rhoads & Klein (1993).

P. appalachianum × *virginianum* has been recorded from 9 of New Jersey's 21 counties (Fig. 3). There is only one collection from southern New Jersey and none from the Pinelands. Records are scattered in northern New Jersey. The lack of records from Sussex and Morris counties is surprising, since both parents are common there.

Polypodium appalachianum has been collected in all of Pennsylvania's 67 counties (Fig. 4), and is well represented from all geographic provinces. There are multiple records for

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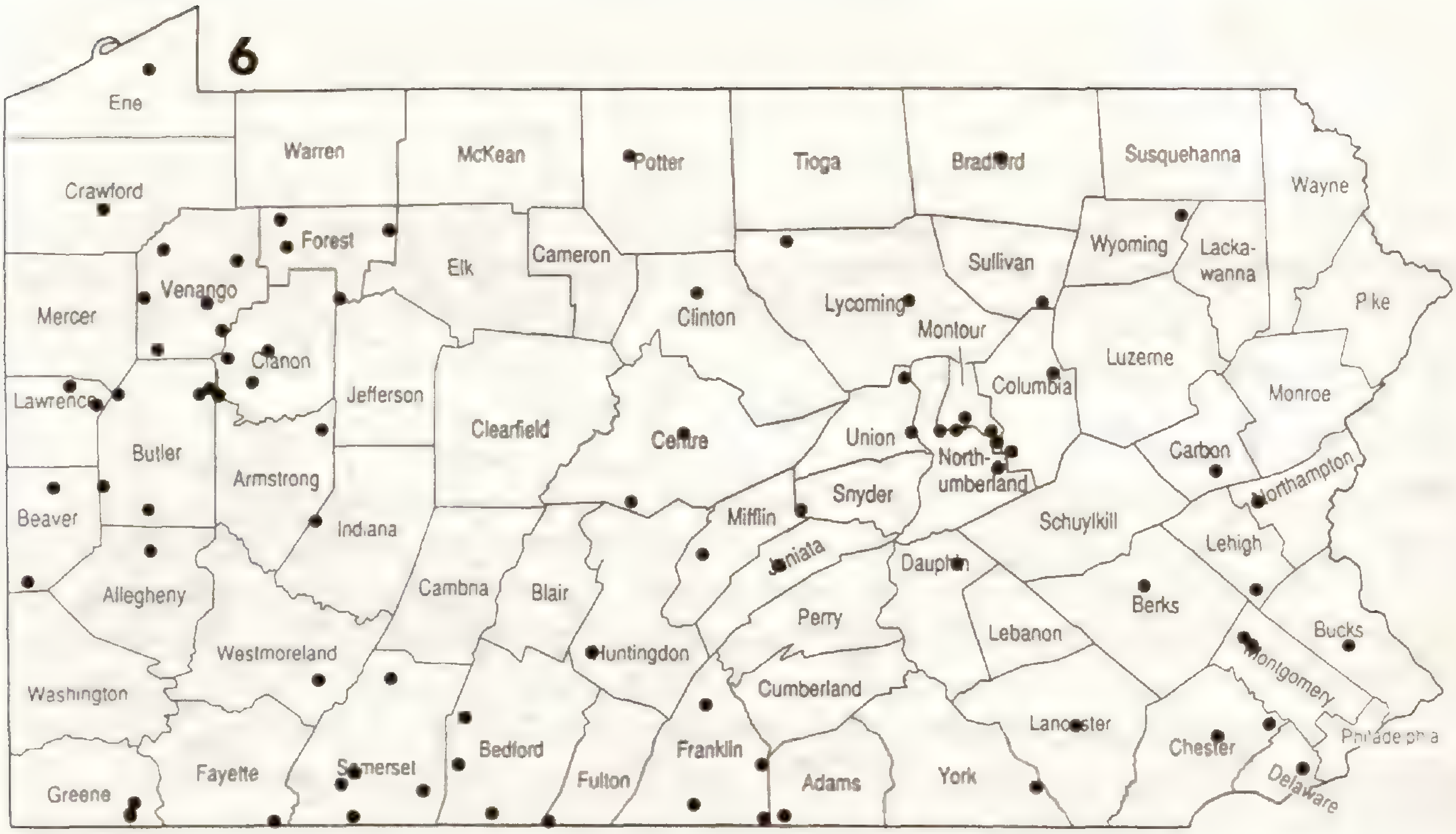
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Fig. 6. Distribution of *Polypodium appalachianum* × *virginianum* in Pennsylvania.

most counties (except Crawford). The higher number of collections from eastern and western Pennsylvania probably reflects more active collectors in these parts of the state, rather than species distribution.

P. virginianum has been collected from 62 of the 67 counties in Pennsylvania (Fig. 5). This species also occurs in all parts of the state, but is apparently uncommon in the north central counties on the Allegheny Plateau. Some of this may be due to collecting bias, but *P. appalachianum* has been collected more frequently in this area. More collecting is needed in Warren, McKean, Potter, Tioga, and Bradford counties.

P. appalachianum × *virginianum* is recorded from 45 of the counties in Pennsylvania (Fig. 6). It has been collected from most parts of the state, but appears to be rare or absent from the Poconos. The hybrid is much less frequently collected than the parents, as indicated by the single records from many counties. The concentrations in Columbia, Montour, and Northumberland counties represent searching by the author. The concentrations in northwestern Pennsylvania represent intensive collecting by C. F. Chuey (YUO) and personnel at the Carnegie Museum of Pittsburgh (CM). The hybrid is probably relatively more common in Pennsylvania than indicated.

Most of the specimens of *P. appalachianum* and *P. virginianum* have been collected on rocks, boulders, ledges, cliffs, or rocky woods. In New Jersey, of the specimens with habitat information on the labels, 45% of the *P. appalachianum* and 37% of the *P. virginianum* were collected in rocky woods or wooded slopes (or some similar combination). Boulders or rocks account for 17% of the *P. appalachianum* and 15% of the *P. virginianum* specimens, and cliffs and ledges 19% of the *P. appalachianum* and 11% of the *P. virginianum*. A few specimens were collected on tree trunks or bases of trees. In southern New Jersey most specimens of both species were collected from sandy banks of streams or roads. A few were collected from old mortar or outcrops of ironstone.

In Pennsylvania 19% of both *P. appalachianum* and *P. virginianum* were collected on rocky woods or wooded slopes, 31% of the *P. appalachianum* and 30% of the *P. virginianum* were collected on boulders or rocks, and 22% of the *P. appalachianum* and 23% of the *P. virginianum* were collected on cliffs or ledges. Smaller percentages were collected on banks, tree trunks or tree bases in Pennsylvania.

The similarity of these figures indicates that there is no difference in habitat between the two species. The differences between the two states are probably a reflection of different habitat availability. New Jersey has a more extensive Coastal Plain and less mountain topography than Pennsylvania.

Of the *P. appalachianum* specimens where a specific type of rock is indicated, 18% were collected on limestone, 59% on sandstone, 16% on shale, and 7% on other rock types (granite, schist, gneiss, conglomerate, or trap rock). Of the specimens of *P. virginianum*, 14% were collected on limestone, 39% on sandstone, 37% on shale, and 10% on other rock types. Neither species shows any affinity for calcareous or acidic rock from these data.

There is less information on which to base conclusions about the hybrid. The same general habitat types as the parents are listed on herbarium labels from both states. Most specimens of the hybrid were collected from sandstone or shale; relatively few were noted as collected on limestone. There is very little data on whether this hybrid usually grows with its parents, but the field experience of the author indicates that at least one of the parents is usually present.

Polypodium appalachianum and *P. virginianum* are both common and widespread species in New Jersey and Pennsylvania. Their habitats and geographical ranges overlap throughout both states. The hybrid is also fairly common. Field botanists in both states should become familiar with these plants.

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Bartonia No. 59: 119-121, 1996

Observation of Polyembryony in *Trillium* and *Smilacina*

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TRILLIUM OBSERVATIONS. Three observations of a pair of germinated embryos emerging from a single seed were made in 1993 during the course of experiments designed to study seed dormany in *Trillium*. Two double-embryo seeds were found in 80 seeds collected from two *T. reliquum* Freeman berries. One appeared in a sample of over 1,000 seeds bulked together from many *T. grandiflorum* (Michx.) Salisb. berries. After root growth reached about 2 cm and frost danger was past, the double-embryo seeds were planted into garden soil, but did not produce cotyledons the next spring. Since these seeds were not dissected, it is not certain that the two embryos were associated with twin endosperms as would be expected if they arose from separate embryo sacs that in turn resulted from the development of both dyad cells. This, however, is a more plausible origin of the observed double embryos than is apomixis from the structures described by Swamy (1948) or Jeffery & Haertel (1947).

The seeds for this work came from plants in the garden at Winterthur Museum, Garden, and Library at Winterthur, Delaware. The Winterthur collection was developed by H. F. du Pont during the early 1900's with significant additions at mid-century. Since some of the species in the collection are now considered rare or endangered, Winterthur's Garden Department wanted to explore the option of propagation from seed of their own specimens. The immediate objective of the author's volunteer research was to find ways to reduce seed germination time from the expected two or more years. The first step was a series of careful observations of the germination of hand-pollinated seeds from the collection. Hand pollination resulted in large numbers of *T. grandiflorum* seeds from the Azalea Woods section of the garden and lesser quantities from the individual specimens of other species.

The germination procedure generally followed the technique proposed by Deno (1993). Freshly harvested seeds were placed in moist paper towels in polyethylene bags at room temperature (about 75°F) until the arils had disintegrated (about a week). The seeds were removed from the towel, rubbed gently in a sieve under running tap water to remove degraded tissue, and returned to a fresh moist towel and bag. In the experiments where double embryo seeds were found, the seeds were held at room temperature for 3 months, stored 3 months at 40°F, and returned to room temperature. The bags were inspected periodically for germination, the removal of rotted seed, and the proper moisture level. The double embryo seeds germinated during the second storage at room temperature. One of the *T. reliquum* double-embryo seeds is shown in Fig. 1.

The *T. reliquum* plants that produced the double-embryo seeds were particularly vigorous. One had two blooming stems, the other had one. Their rhizomes grew at the soil line beneath two to three inches of oak leaf litter that protected the leaves from damage due to rain-splashed soil. The environment had been stable for at least three years because a clump of seedlings, some with monofoliate and some with trifoliate leaves (two and three year plants) grew where a berry had fallen and shed seeds that were not carried off by ants.

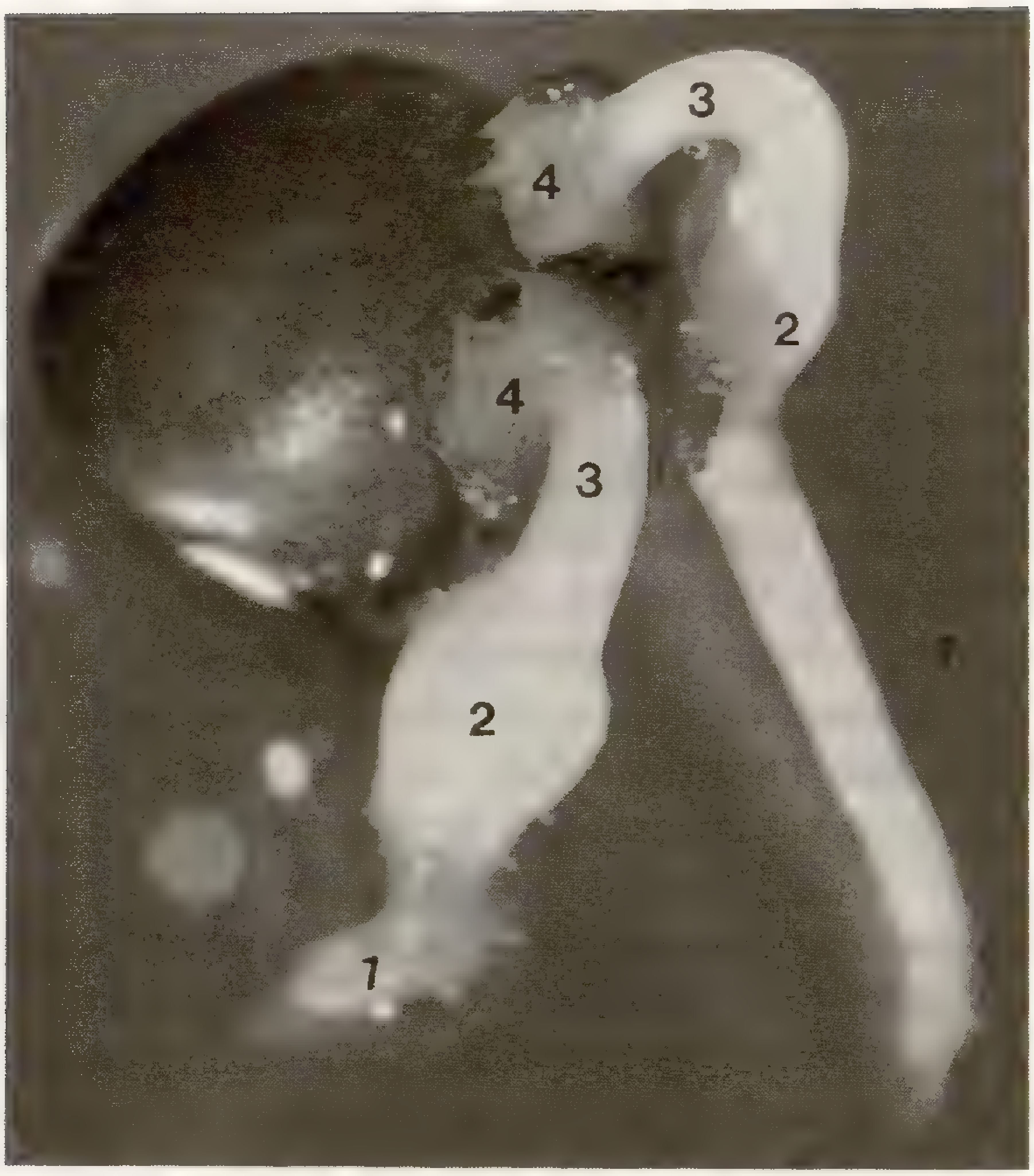

Fig. 1. Two germinating embryos emerging from a single seed of *Trillium reliquum* Freeman. 1 = root, 2 = rhizome, 3 = cotyledon petiole, 4 = collar of starchy endosperm.

The two adult plants were cross-pollinated twice in May and the berries were harvested in August. The strong growth of the plants and the high density of pollen on the stigmas undoubtedly contributed to the development of double-embryo seeds.

The double-embryo *T. grandiflorum* could not be traced to an individual plant, but the Azalea Woods population at Winterthur contains numerous very strong plants and is actively reproducing. No photograph was taken of this double-embryo seed, but recently Solt (1995) photographed a double-embryo *T. grandiflorum* in the course of her research.

The origin of double-embryo seeds in *Trillium* has not been previously reported, but Jeffery & Haertl (1939a & 1939b) claim that apomixis exists in *Trillium* while Swamy (1948) reports the development of multiple embryo-like structures in the developing endosperm of *T. undulatum* Willd. Although either process could produce multiple embryo seeds, neither author reports observing multiple mature embryos or the germination of multiple embryo seeds. The Jeffery & Haertl report of apomixis is not supported by Howe (1940), the detailed work of Blain (1945), or that of Berg (1958 & 1962). In fact Berg (1962) states, "Apparently a statement by Jeffery and Haertl should be assumed wrong rather than correct, unless sustained by observations made by other investigators." Swamy reports multiple embryo-like structures in 19% of the fertilized *T. undulatum* Willd. ovules he examined. If Swamy's embryo-like structures occur in other *Trillium* species and commonly result in viable embryos, the large number of seeds germinated in the Winterthur experiments should show numerous instances of multiple embryo germinations. They do not. Only double-embryo germinations were observed and these were very rare.

The simplest explanation of the origin of twin embryos is to hypothesize that both dyad cells in the developing megaspore continue to grow and are fertilized. This would result in two embryos each with its own endosperm encased in a single integument. Since one dyad cell disintegrates under normal conditions, the development of both may be favored by particularly strong plant growth while the fertilization of both would be favored by a heavy load of pollen on the stigma. Both of these conditions existed for the *T. reliquum* plants when they produced the observed double-embryo seeds.

SMILACINA RACEMOSA OBSERVATION. A pair of germinated embryos emerged from a single seed of *Smilacina racemosa* (L.) Desf. during experiments based on Deno's (1993) germination protocol as summarized above. The seed population was from a single panicle collected in September. The berry pulp was removed by gentle abrasion in a sieve under running tap water. The twin embryos produced roots about five cm long before they were planted with normal, single-embryo seeds near an existing population in a deciduous woods. No photographs were taken of the twin embryo seed.

Gorham (1953) described normal early megaspore development in *S. racemosa*, stating that the upper dyad cell develops into an embryo sac while the lower disintegrates. If both dyads survived, produced embryo sacs, and were fertilized, then twin embryos could form as is hypothesized for *Trillium*.

Gorham's (1953) claim of apomictic seed production is accompanied by these observations that suggest the possibility of unobserved fertilization: (1) viable pollen, (2) pollen tubes growing in stylar tissue, (3) pollination required for seed development, (4) polar nuclei that "—fuse suddenly, some time after pollination," (5) degeneration of ovules that do not produce endosperm.

A fully satisfactory explanation of the development of the twin embryos in the double-embryo seed germinated in my experiments awaits the application of currently available techniques in a reinvestigation of reproduction in *S. racemosa*.

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Bartonia No. 59: 123-124, 1996

The Gold-Cone Tamarack (*Larix laricina* forma *lutea*, Pinaceae) in Pennsylvania

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During field work in Bradford County, Pennsylvania, in June 1994 we explored a tamarack (*Larix laricina*) swamp near Troy. There, among the many purple-coned tamracks we noticed a single tree that stood out quite obviously from the rest: its cones were clear yellow without a trace of purple. Cone color was the only difference we noted between the yellow-coned tree and the other tamaracks. We had never seen a yellow-coned individual even though we have, between us, observed tamaracks in nine Canadian provinces from Newfoundland to Alberta, in Canada's Northwest Territories, and in the U.S. from Maine to Minnesota.

Later investigation in the literature revealed that a yellow-coned "variety" of *L. laricina* was described in a paper on North American *Larix* by Jaurès and de Ferré (1949) as var. *lutea* Jaurès: "A laricina typica differt strobili colre luteo." The type specimen (at Harvard University Herbaria [A!]), said to be from a cultivated tree, was collected by J. B. Moyle (no. 172) on 5 Jul 1930 in a "Forest Nursery" in Clearwater County, Minnesota. Our inquiry among several foresters in that county revealed that such a nursery no longer exists; none of the foresters to whom we spoke recalled seeing a yellow-coned variant of tamarack.

Further investigation revealed that most of the descriptions of *L. laricina* we checked make no mention of such a variant. Even *Flora of North America* describes the seed cones as being "at first dark red to violet, later turning yellow-brown" (Parker 1993). The cones on our tree were certainly not "at first dark red to violet."

Den Ouden & Bloom (1965), treating the variant as a form (a rank we consider appropriate), published the new combination *L. laricina* "forma *lutea* (Jaurès & de Ferré) den Ouden & Boom." Of the plant they wrote "Flowers yellow; found in Clearwater County, U.S.A."

Farjon (1990) included "var. *lutea* Jaurès et Y. de Ferré" in synonymy under *L. laricina*. However, in his description of the cones of that species, "yellow" does not appear. He wrote of their color as being "light red or greenish" when immature and "orange-brown with purplish tinge" at maturity.

Welch & Haddow (1993) listed "forma *lutea* Den Ouden/Boom." They commented that the variant was "named for a tree bearing yellow flowers found in Clearwater County, Pa. [sic]"

Only three infraspecific epithets—none of them *lutea*—appear under *L. laricina* in Cope (1986). And, finally, in all of *Larix* the only infraspecific taxon based on cone color appears to be "var. *lutea*" of *L. laricina* (Krüssmann 1970).

Jaurès & de Ferré stated that intermediates between their var. *lutea* and the "forme typique" are frequent. These authors worked only with herbarium specimens; we suspect that sharp distinctions between the color variants become blurred as the specimens fade with age. Such fading may be evident on the holotype: the scales of its cones, after some 66 years in a herbarium, are now light brown (tan) with no trace of purple. The small bracts subtending the cone scales are somewhat darker brown.

Authorship of the epithet *lutea* is given by several authors (Farjon 1990; den Ouden & Boom 1965; Krüssmann 1970) as "Jaurès et de Ferré." In the original publication of the epithet no authorship is indicated at the place (page 6) where var. *lutea* (one of two varieties proposed under *L. laricina*) is described. Elsewhere in the paper, though, the statement is made (page 2) that "Ces deux variétés s'appelleront: *L. lutea* et *L. parvistrobus* Jaurès." Clearly de Ferré has been excluded.

Tamarack appears to be less common in cultivation than some of its Old World congeners. The yellow-coned variant, being unusual, might well be desirable as a specimen plant. We sugest the name "gold-cone tamarack" for it.

Further observations on the occurrence of this variant would be welcome.

Our voucher specimen is deposited in the herbarium of Northern Kentucky University (KNK): Pennsylvania, Bradford County, in *Larix* swamp, along S side of Fallbrook Road, 0.3 mi W of jct with Swamp Road, ca. 4 mi SW of Troy, 15 Jun 1994, *Naczi & Thieret 4225*. We collected a sheet of the typical tamarack, with its purple cones, at the same time *(Naczi & Thieret 4221,* KNK*)*.

We thank Dr. David E. Boufford and Dr. David M. Brandenburg for aid.

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Bartonia No. 59: 125-128, 1996

Paintings of Fungi by Lewis David von Schweinitz in the Archives of the Academy of Natural Sciences of Philadelphia

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The Academy of Natural Sciences of Philadelphia has a rich and remarkable collection of historical botanical items including the herbaria of many famous American botanists, books, manuscripts, and works of art. In its collection, the Academy is fortunate to have Volumes I, II, III, and V of *Fungorum Nieskiesium Icones* [*Icones*] (1804) by Lewis David von Schweinitz (1780-1834). These four volumes include over 1,000 original paintings of fungi species. They are expertly and artistically rendered in watercolor by Schweinitz, and after nearly 200 years still retain their vivid color and beauty. A review of the species illustrated in Icones indicates that 71 are those that were originally described by Schweinitz and his mentor Johannes Baptista von Albertini in their published work *Conspectus Fungorum in Lusatiae superioris agro Niskiensi crescentium e methodo Persooniana* [*Conspectus*] (1805). Although the number and quality of the original paintings in the four volumes is exceptional, they are archival materials that have had very limited recognition or appreciation. In order to generate further interest and draw the attention of the mycological community to these historical paintings, a listing of the 71 species that were newly described in *Conspectus* and occur in *Icones* is provided in Table 1.

Lewis David von Schweinitz was born in Bethlehem, Northampton County, Pennsylvania, on February 13, 1780. His great-grandfather Nicholas Lewis Count Zinzendorf, was the founder of the Unitas Fratrum or Moravian Brethren church, and his father was in charge of the fiscal and secular concerns of the Moravian Brethren in America (Pennell 1934). From the age of seven to seventeen, Schweinitz was sent to study at the all boys school, Nazareth Hall, in the Moravian community near Bethlehem. At Nazareth Hall, Schweinitz came under the tutelage of Samuel Kramsch, a minister for the Moravian church and an ardent botanist (Barnhart 1934). Under Kramsch and in the company of Christian Frederick Denke, a fellow student and botanist, Schweinitz's interest in botany began.

In 1798, the von Schweinitz family moved to Germany, and Schweinitz entered the Moravian Theological Seminary at Niesky in Silesia. There he met Professor Albertini, who was also intensely interested in botany. Together Schweinitz and Albertini collected and studied fungi throughout the Niesky region and in 1805 published their Conspectus, which contained descriptions of 1,130 fungi species including 127 newly described species. It was during this same time period, probably in conjunction with the development of Conspectus, that Schweinitz painted Icones. The *Conspectus* established Schweinitz's and Albertini's reputation among European mycologists leading to an honorary degree for Schweinitz from Kiel. This work and two subsequent works by Schweinitz alone on fungi, *Synopsis Fungorum Caroliae superioris secundum obervationes* in 1822 and *Synopsis Fungorum in*

America Boreali media degentium in 1932, and his large herbarium are responsible for designating Schweinitz as the founder of mycology in America (Benedict 1934). Although interested in all the fields of botany throughout his life, von Schweinitz's chief interest was fungi (Benedict 1934). For more complete information on Schweinitz, see Bartonia No. 16, 1934.

In 1834, when Schweinitz died, his large herbarium was bequeathed to the Academy of Natural Sciences of Philadelphia. So extensive was his herbarium (23,000 species) that the Academy's previous herbarium was simply added to the Schweinitz series (Pennell 1934). In 1903, George E. de Schweinitz presented *Icones* volumes 2, 3, and 5 to the Academy, and in 1913, Mrs. W. A. Lemly (Emily de Schweinitz Lemly) donated volume 1 to the Academy. A letter from the librarian at the University of North Carolina at Chapel Hill states that volume 4 is at this institution (Phillips and Phillips 1963). Years ago Eugene A. Rau stated that he had seen seven volumes of *Icones* (Phillips and Phillips 1963). Assuming this to be the case, the whereabouts of volumes 6 and 7 is unknown. We are proceeding on with a project to list all the fungi in Schweinitz's *Icones* with their associated names and descriptions from the Conspectus.

Table 1. Species newly described in *Conspectus* and also illustrated in *Icones* Volumes I, II, III, and V

Species in *Conspectus*	Volume	Plate	Figure
Sphaeria lutea	I	9	2
Sphaeria rimosa	I	11	2
Sclerotium vaporarium	I	37	2
Sclerotium scutellatum	I	38	2
Lycogala atrum	I	49	3
Licea strobilina	I	60	3
Aecidium Violae	I	65	3
Amanita porphyria	II	82	8
Agaricus bulbiger (under Lepiota in *Icones*)	V	354	245
Agaricus porphyropus (under Cortinaria in *Icones*)	II	112	75
Agaricus lepidomyces (under Cortinaria in *Icones*)	V	356	251
Agaricus luteo-virens (under Gymnopus in *Icones*)	II	117	91
Agaricus subglobosus (under Gymnopus in *Icones*)	II	114	83
Agaricus camarophyllus (under Gymnopus in *Icones*)	V	359	259
Agaricus vitellum (under Cortinaria in *Icones*)	II	102	50
Agaricus purpurascens (under Gymnopus in *Icones*)	V	361	263
Agaricus tricholoma (under Gymnopus in *Icones*)	V	360	261
Agaricus scabellus (under Gymnopus in *Icones*)	II	161	208
Agaricus tricolor (under Omphalia in *Icones*)	V	374	303
Daedalea rubescens	V	381	3
Boletus sistotremoides (sistotrematoides in *Icones*)	V	384	52
Boletus confluens	III	181	11
Boletus roseus	V	389	59
Boletus sanguinolentus	V	391	64
Sistotrema pendulum	V	393	10
Sistotrema viride (aeriginosum in *Icones*)	III	199	5
Hydnum violascens	V	395	19
Hydnum fasciculare	V	399	26
Hydnum castaneum	V	398	25
Hydnum bicolor	V	398	23
Hydnum calvum	III	206	13
Hydnum calvum	V	399	27

Table 1 (cont'd)

Thelephora sanguinolenta	III	211	9
Thelophora punicea	V	402	36
Thelophora concentrica	V	401	35
Thelephora marginata	III	219	31
Leotia truncorum	V	411	5
Helvella fistulosa	V	414	6
Tremella saligna	III	235	8
Peziza clavus	V	423	120
Peziza betuli	III	240	9
Peziza fusco-cana	III	241	10
Peziza carbonaria	III	242	15
Peziza fascicularis	III	243	16
Peziza digitalis	V	418	105
Peziza membranacea	V	419	109
Peziza brunnea	III	250	44
Peziza flavo-fuliginea	III	251	45
Peziza flammea	III	250	43
Peziza rufo-olivacea	V	422	117
Peziza theleboloides	V	423	121
Peziza albo-violascens	III	252	49
Peziza leucotricha	V	422	116
Peziza sericea	III	247	31
Peziza porioides	III	251	46
Peziza lonicerae	III	251	47
Peziza laciniata	III	257	65
Peziza sanguinolenta	III	261	80
Peziza virens	III	261	81
Peziza betulina	III	261	79
Peziza verrucaria (verucaria in *Icones*)	V	422	118
Peziza pulveracea	III	265	93
Peziza ledi	V	424	123
Peziza conoplea	V	422	119
Ascobolus lignatilis	III	267	3
Stilbum hyalinum	V	426	11
Periconia flavovirens	V	430	4
Ceratium porioides (poroides in *Icones*)	V	429	2
Isaria monilioides	V	432	4
Erineum betulinum	V	445	8
Mesenterica grisea	V	452	2
Mesenterica sanguinolenta	V	453	3

ACKNOWLEDGMENTS

I thank A. E. Schuyler at the Academy of Natural Sciences of Philadelphia for suggesting this project and directing me throughout its preparation, and Carol Spawn for access to the archived artwork of Schweinitz at the Academy.

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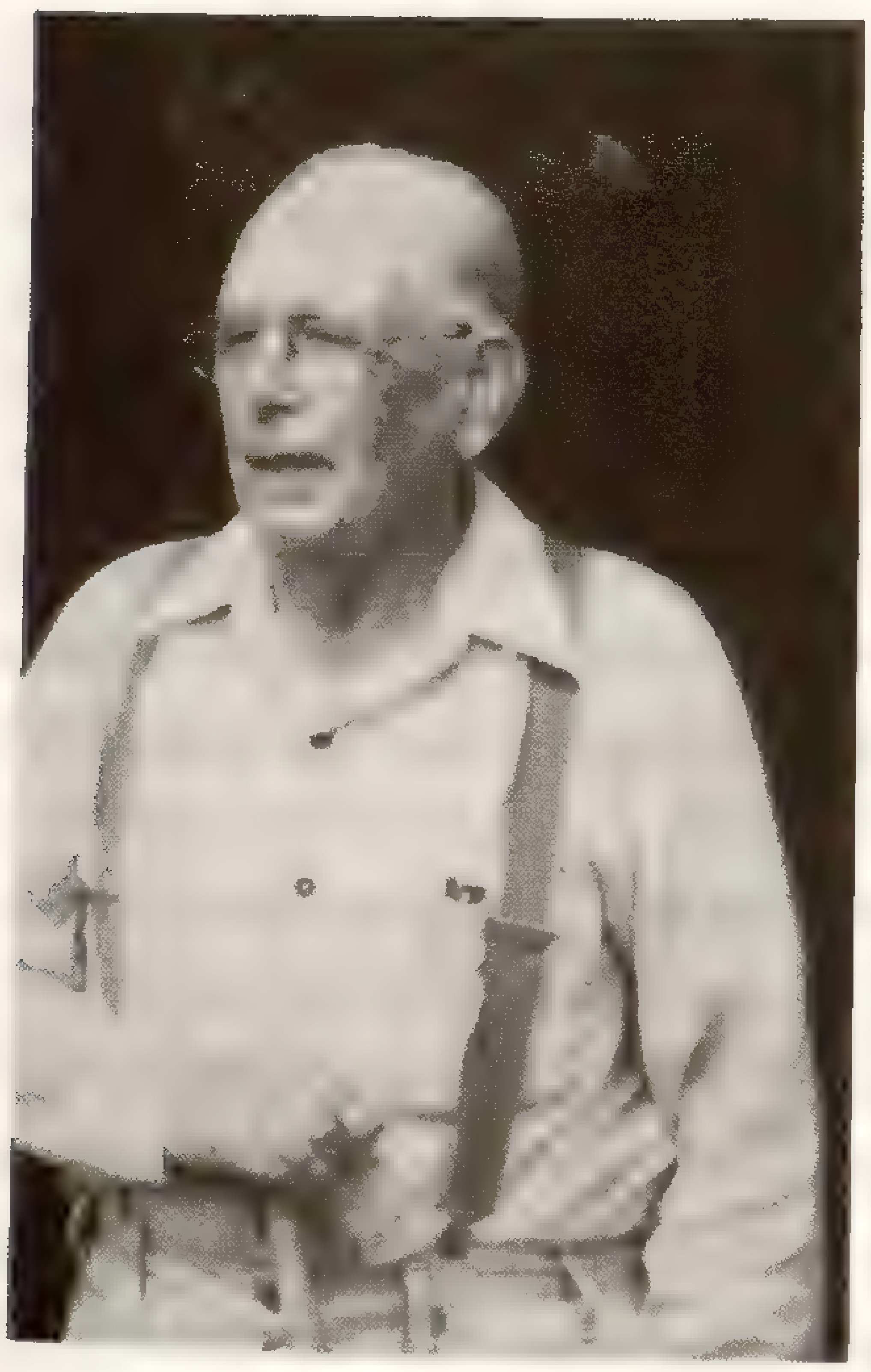
Bartonia No. 59: 129-133, 1996

OBITUARIES

Gilbert Raymond Cavileer (1911-1992)



On 1 January 1992, Gilbert Raymond Cavileer, Pine Barrens native and natural history counselor, died in Philadelphia's Hahnemann Hospital. His was the passing of yet another extraordinary field botanist, approximately 3 years after the death of Louis Edwin Hand (Bartonia No. 55:1-3, 1989).

I met Gil through Joseph M. Welch, then Assistant Manager of Brigantine National Wildlife Refuge, when I was working in Washington, D.C. It was the beginning of an enduring friendship of over 3 decades. At first when we got together, were mainly explored the Pine Barrens; in recent years we were more likely to visit such places as Brigantine National Wildlife Refuge, South Cape May Meadows and Higbee's Beach, Corson's Inlet, the Seven Bridges area near Tuckerton, or Brigantine Beach. My memories of Gil are thus intertwined with pitch pine stands, cedar bogs, sand and surf, the tangy smell of the salt marsh, monarchs migrating, snow geese yipping—in summary, a host of priceless hours, shared with a cherished companion.

Gilbert was of English, Dutch, and Irish background. His ancestors included lineages which trace their history in America to the 1600s, for example Cavileer, Veale and Claypool, and the late 1700s and early 1800s, for example Endicott and Maloney.

Gil was the oldest of three boys (a 4th child, James C., died in infancy in 1924). William M. was born in 1917 and Watson S. in 1922. Bill was mainly a boat builder; he is now a part-time security guard at William B. Kessler Memorial Hospital in Hammonton, New Jersey. Watson became the Supervisor of Manufacturing for Beckman Instruments in Fullerton, California; he died several months after Gil.

Their father, Raymond S. (1879-1933), had a variety of occupations, largely oriented to the sea. He was a sea captain—with 2 brothers he owned a vessel, and with a cousin he owned a shipyard in Camden, New Jersey; he also was a boat builder, clam digger, clam and oyster buyer, carpenter, and farmer.

Their mother, May Maloney Cavileer (1887-1977), was a nurse and teacher. She was a warm and cheerful person, who would sing while doing house work. Her "fling for the year," as Bill Cavileer expressed it, was an annual trip to the Atlantic City racetrack. In her declining years she moved to California, where Watson and his family were living, to be in a warmer climate.

Gil's mother probably was more influential in his life than was his father; certainly she was home nearly all the time, whereas Gil's father often was away from home. Also Gil's father favored Bill over the other boys. However, Raymond Cavileer's admonition, "If you can't improve on silence, keep quiet," definitely was part of Gil's philosophy.

The family home was on the edge of the Pine Barrens in Port Republic, New Jersey. The Cavileers grew their own vegetables, had chickens and turkeys, raised pigs which were bedded in marsh hay harvested by the boys, and obtained a variety of fish and shellfish from nearby creeks, inlets, and bays. Young Gilbert was curious about animals; he brought home snakes and turtles, and at age 12 was given a subscription to *Nature Magazine.* The house was always full of books, and the boys were also exposed to classical music and opera from a crank-up Victrola.

After graduating from Egg Harbor City High School, Gil dug clams and trapped for a while before heading west. These were depression years, when a popular song was "Brother, can you spare a dime?" During these years, Gil worked at Civilian Conservation Corps camps in Idaho and California, and ranches in California. He was building boats in Atlantic City when he was drafted into the U.S. Signal Corps in World War II. Sent to Germany, he stayed there for about a year and a half after the war ended, replacing communication lines. He then returned to New Jersey and lived with his mother. When jobs were scarce after the war, Gil and Bill pulled sphagnum moss and sold it to nurseries, but Gil made his living mainly as a boat builder and clam digger.

He never married. A special friend of recent years was Betty Hann of West Wildwood, New Jersey.

Gil's residence from 1955 until his death was 106 Main Street in Port Republic. The left part of the house was built between 1790-1800, and the right half in about 1870. Housekeeping and record keeping were relatively low on Gil's list of priorities. I would return after a year's absence, for example, to find that the open space on the kitchen table had become even smaller because of the proliferation of more magazine, letters (some unopened), announcements of meetings (past, present, and future), subscription blanks, financial appeals, utility bills, Social Security forms, bank slips, discarded (?) silverware, salt and pepper shakers, pill containers, pens and pencils, erasers, plant remains (vascular and non-vascular), etc. I often thought of the table top as a potential archaeological site! A similar fate overtook the house in general, and also his truck. It was not at all unusual to find a stray item of interest, for example a vintage letter, in an odd and unexpected place.

Gil essentially was a self-taught naturalist, although he did take a few courses, for example at the Wetlands Institute in Stone Harbor, New Jersey. For the identification of vascular plants, he used both Gray's Manual and Britton and Brown, but preferred the keys in Gray's. In the field he carried an 8× hand lens, and at home he had a binocular microscope. His knowledge of natural and local history was legendary, and always freely shared.

He led wildflower walks and gave programs for a number of organizations, for example, the Philadelphia Botanical Club, the Wetlands Institute, the Cape May Geographic Society, the Audubon Society, and the Jersey Cape Shell Club. He was a member of the Philadelphia Botanical Club and the New Jersey Chapter of The Nature Conservancy. With John Gallegos, Gil conducted rare plant surveys in the late 1970s and early 1980s in four acid meadows: Big and Little Goose Ponds, Barkwoods Pond, and Hirst Pond. The results are detailed in two unpublished reports, and in a paper, "The influence of fluctuating water levels upon the incidence of rare plant species of southern New Jersey," which was read at a meeting of Stockton College in Pomona, New Jersey. Gil also assembled vascular plant lists of other areas, for example the Holgate Unit of Brigantine National Wildlife Refuge, The Nature Conservancy's South Cape May Meadows, and the U.S. Coast Guard Station at Cape May. In his latter years he worked part-time for Inman Environmental of Pleasantville, New Jersey, where among other duties he assisted in compiling a vascular plant list of Atlantic County. He collaborated on Snyder and Vivian's Rare and Endangered Vascular Plant Species in New Jersey, which was published in 1981, and looked for endangered species at Brigantine National Wildlife Refuge in more recent years. Gil also banded birds for a number of years.

He also traveled whenever his finances and health allowed it. In the latter part of his life he journeyed to the northeastern United States and far eastern Canada, Florida, Wisconsin, the northwest, and the southwestern United States. On one western trip he was joined by Ernest A. Choate and on another by the author of this obituary, but usually he traveled alone, staying with friends at his destination. His field companions over the years included Hollis Koster of Green Bank, Frank Hirst of Stockton, Maryland, Keith Seager of Cape May, and David B. Snyder of New Jersey's National Heritage Program.

Gil continued his botanical explorations up to the time of his fatal illness. On one of our last outings, we were joined by Seager and Snyder on a hot, muggy day near Cold Spring in Cape May County; we visited two areas, one for the spike-rush *Eleocharis halophila*, and the other for the rush, *Juncus coriaceus*. The heat index was 100 degrees F, and we were all feeling its effects, especially, or so it seemed, Gilbert, who suddenly blacked out and collapsed after our last hike. But I wondered if it was entirely from the heat, because he had told me he had been having dizzy spells recently. A few days later, when we said goodbye at the Pomona Airport, I wondered if we would ever get together again. On the phone a few weeks later, Gil told me that he had Lyme Disease, but this diagnosis proved to be incorrect. He had leukemia. His condition worsened, and he died in the hospital. In his younger years Gil sometimes walked on a beach in a storm; there was a strong Northeaster on the day of the funeral, and, as Budd Wilson, Jr., a long-time friend of Gil's, wrote in a letter to me, "Somehow going out in a Northeaster seemed appropriate for Gil." He was buried in the family plot by St. Paul's Methodist Church in Port Republic.

When asked about his health, Gil was apt to say, "Struggling along." His attitude toward life was simple and to the point: enjoy each day, yet realize that death is natural and inevitable.

Snyder and Seager took responsibility for Gil's herbarium. Earlier collections are at the Academy of Natural Sciences and Rutgers University.

Peter Kalm, a Swedish naturalist and student of Linnaeus, met John Bartram in 1748; his comments about the Quaker botanist remind me of Gil, and might serve as his epitaph: "He has acquired a great knowledge of natural philosphy and history, and seems to be born with a peculiar genius for these sciences .... We owe to him the knowledge of many rare plants which he first found .... He has shown great judgment and an attention which lets nothing escape unnoticed. Yet with all these qualities . . . he did not care to write down his numerous and useful observations .... I have often been at a loss to think of the sources whence he obtained many things which came to his knowledge. I, also, owe him much, for he possessed that great quality of communicating everything he knew" (Peter Kalm's Travels in North America. The English version of 1770. Revised from the original Swedish and edited by Adolph B. Benson. Volume 1. Wilson-Erickson Inc., New York, 380 pages, pp. 61-62).

I thank Bill Cavileer for information on Gil and the Cavileer family, and Keith Seager for biographical details. The photo for this obituary was taken on 17 September 1981 near Cold Spring, Cape May County, New Jersey.

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Charles T. Brightbill (1935-1994)

On July 26, 1994, Pennsylvania lost one of its most valued teachers, naturalists, photographers, historians, and friends, Chuck Brightbill, who died after struggling more than a year with cancer.

Born in Chambersberg, Pennsylvania, on November 25, 1935, Chuck lived most of his adult life in nearby Mercersburg. He was a 1958 graduate of Lebanon Valley College and received a master's degree in music education in 1968 from Trenton State College, New Jersey. He taught music, mostly elementary and vocal and beginning band instruments, for 10 years in New Jersey and retired in 1989 after 21 years in Pennsylvania.

I first met Chuck in the summer of 1979 while he was ecology director at Sinoquipe Scout Camp. That summer I retook Bird Study merit badge so that I could learn more about birds; I had already heard about Chuck's reputation as a keen birder. I remember vividly the first contact I had with him as he and I stood on the porch of the Dining Hall and he pointed out a chipping sparrow singing in a Virginia pine. For 15 years Chuck was a close friend and mentor—he encouraged my interests in biology and taught me to cherish knowledge and share it with others through walks and slide presentations. Chuck, his mother, my parents, and I took many trips together, sometimes solely for birding while other times solely for plants; for several years, we spent New Years birding at Chincoteague, Virginia.

Chuck was best known for his nature walks and slide presentations. His personality and teaching methods aided children and adults in their enjoyment of his talks. He developed presentations based on his travels (e.g., "Wildlife of Alaska"—the photo in this obituary was taken while he was birding in Alaska on 16 July 1978), the local flora and fauna, and historical events. He was a talented actor; thus, in his historical presentations he was well-known for giving talks on special topics and dressing as an Indian, frontiersman, Civil War soldier, or Scot Highlander. In fact, he took his role so seriously as to get a Mohawk haircut instead of wearing a wig.

Chuck was active in various community organizations and served several leadership capacities: Tuscarora Education Association, Conococheague Audubon Society, Boy and Cub Scouts, Towne Singers in Chambersburg, Fort Loudon Ruritan Club, three local historical societies, and the Maryland Ornithological Society in Washington County. He volunteered for 17 years with the Pennsylvania Bureau of State Parks and worked for 6 summers as a nature director at Cowans Gap State Park. He helped to organize the Tuscarora Wildlife

Education Project and its Natural History Museum, and was involved in rebuilding the historic Fort Loudon on the original site.

Chuck, as a self-taught botanist, gave leads to rare plants and special habitats in Franklin County, Pennsylvania. For example, Chuck for several years led a field trip to southwestern Franklin County for the Conococheage Audubon Society (in which I participated), and stopped at a mesic upland woods to show the luxurient herbaceous layer. Chuck recognized that the flora as unusual but never thoroughly investigated it. Starting in 1986, Dr. Larry Klotz (Shippensburg University, Pennsylvania) and I studied the flora in detail and recorded five state rarities including one species new to the state (see Bartonia 56:29-33; 1990). Larry and I led a field trip for the Philadelphia Botanical Club to this area on 5 May 1991 (see Bartonia 58:141-142; 1994). Chuck also gave us leads on several additional rare species in the nearby area as well as the bluffs along the West Branch of the Conococheague Creek (see Bartonia, Supplement to 57:16-41; 1993).

Chuck will be immensely missed, but will be remembered for his work. The nature center at Cowan's Gap was named "Brightbill Interpretive Center" in 1994, and the museums at the James Buchanan High School for the Tuscarora Wildlife Education Project and at the Fort Loudon Historical Site will be named after him. In 1994, he received the Meritorious Service Award from the National Audubon Society.

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Bartonia No. 59: 134, 1996

REVIEW

Pennsylvania Higher Plants Volume I. Field Manual, by James A. Schmid. Schmid and Company, Inc., Media. 1994. 182 pp. $35.

New Jersey and Pennsylvania Higher Plants Volume II. Desk Manual, by James A. Schmid and John T. Kartesz. Schmid and Company, Inc., Media. 1994. 443 pp. $55.

These two volumes are an attempt to make available to others the working files of the Schmid and Co. regarding the wetland indicator status and state and federal rare plant classification of vascular plants. While the compact size of Volume I (5 × 8 in.) may make it a handy field reference, the term manual is misleading. In fact this book is a list and the information therein only accessible to one who has already identified the plants in question.

Volume I actually consists of two lists, one alphabetical by genus and species and a second alphabetical by common name; family name and wetland and rarity codes are repeated in each section. It has taken some ingenuity to come up with unique common names for each species in the list, an effort that has involved inventing names for some sedges and other plants that do not have generally accepted common names. Schmid and Co. have also augmented the U.S. Fish and Wildlife Service wetland indicator codes, based on their own field experience.

Volume II repeats the information in Volume I with the addition of rather cryptic coded notes on historic wetland indicator status, according to several other sources, and a growth habit code. While Volume I includes some synonymy in the alphabetical listings, Volume II contains a more extensive listing of "Obsolete Latin Names" referenced to "Current Latin Names." The larger format of Volume II (8.5 × 11 in.) makes it less useful in the field, perhaps one characteristic in its favor, however, is the inclusion of lists for both Pennsylvania and New Jersey. For a user interested in only Pennsylvania, there is little to be gained by investing in Volume II, the Rhoads and Klein 1993 *Vascular Flora of Pennsylvania: Annotated Checklist and Atlas* (American Philosophical Society, Philadelphia) is a much better buy at $50. It also contains wetland and rarity status as well as synonymy, growth habit, habitat and distribution maps for each species within the state.

According to the introductions in both volumes, the 3373 Pennsylvania plants inlcuded in these references were derived from a list compiled by John Kartesz and represent species "known to grow wild or to persist without continued, deliberate cultivation . . . plus a few weedy exotics that we have encountered thriving in the field but not found in previous reports." This compares with 3318 taxa included in the Rhoads and Klein book. Diffrences in taxonomic interpretations account for some of the discrepancy. However, the scientific validity of Schmid and Kartesz' work would be enhanced if the source of their records were more clearly defined and new state records of occurrence were properly vouchered with herbarium specimens.

Ann F. Rhoads

Bartonia No. 59: 135-137, 1996

NEWS AND NOTES

FIRST RECORD OF *DRYOPTERIS CLINTONIANA* (D. C. EATON) DOWELL IN LANCASTER COUNTY, PENNSYLVANIA. While botanizing in a familiar spot near Safe Harbor, in Lancaster Co., PA, on September 26, 1994, James C. Parks discovered a population of about 30 plants of the fern genus *Dryopteris*. The plants were of various sizes, indicating a stable, reproducing population. They were growing on an elevated flood plain terrace above a small stream in a generally steep-sided, forested ravine. The overstory trees were *Platanus occidentalis* and *Acer negundo*. The shrub layer contained *Lindera benzoin*. Herbs present included *Hemerocallis*, *Impatiens* spp., and *Polystichum acrostichoides*. The largest *Dryopteris* ferns grew at the edge of the terrace at the base of a steep slope, in rich, organic soil, but several small ones were near the streamside bank. The largest fonds exceeded 0.8 m in length and were initially thought to be *D. celsa* or a hybrid of it. Both are reported from further south in Lancaster Co. Careful examination of specimens led Parks to determine that they were *D. clintoniana*. Subsequently, this determination was confirmed by James T. Montgomery. He noted that the basal pinnae were triangular, the scales a uniform, dull brown, and very few sporangia had not shed, all indicative of this fertile hexaploid species. Specimen records, provided by Ann Rhoads from the Flora of Pennsylvania Database at the Morris Arboretum, indicate that *D. clintoniana* is recorded from York and Dauphin Counties but that most of the PA records are from the glaciated northeastern region. As Montgomery observed, *D. clintoniana* has a strange distribution in Pennsylvania and is uncommon even where it is found. This thriving population is the southernmost known in Pennsylvania and adds to this perplexing distribution. Voucher specimens have been deposited at The Academy of Natural Sciences of Philadelphia (PH) and Millersville University (MVSC). J. C. PARKS AND J. T. MONTGOMERY.

1993 NORTHERN DELAWARE RARE PLANT SURVEY HIGHLIGHTS. The 1993 botanical field season in New Castle County and northern Kent County proved fruitful in the discovery of new state records, relocations of historical records, and of new rare plants sites. In the Brandywine drainage of the Piedmont physiographic province, discoveries included the first record of *Cardamine angustata* (S2) for that drainage (previously only known from the Red Clay Valley); Delaware's second site for *Veronicastrum virginicum* (S1); new stations for *Andropogon gerardii* (S1) and *Bromus pubescens* (S2); and a modern record for the more northern *Callitriche palustris* (former SH). The Red Clay drainage yielded a second site for *Carex granularis* (S1) and the first site for *Carex gracilescens* (former SH); *Euonymus atropurpurea* (former SH) growing near new populations of *Smilax hispida* (S1) and *Andropogon gerardii*; *Juncus subcaudatus* (S1) growing in a low wet meadow; and finally *Leptoloma cognatum* (former S1) growing in abundance on a dry roadbank and an adjacent mown pasture. The White Clay drainage produced the new state record *Agrimonia striata*; a third Delaware station for *Heliopsis helianthoides*; and *Zannichellia palustris* (former SH). Other Piedmont drainages also provided *Calystegia spithamaea* (former SH) in bloom in a young dry open woods; Delaware's second extant station for *Chamaelirium luteum* (S1); a third population of *Geum vernum* (S1); two stations of the new state record *Osmorhiza claytonii*; and *Stellaria longifolia* (former SH). An additional find was a small but healthy blooming population of *Trillium erectum*, not seen in the state for over a century, and in an apparently native setting.

On the Coastal Plain of central and southern New Castle County, finds included a second population of *Zannichellia palustris* in a tidal habitat; two populations of *Silene virginica* (former SH); a second population of *Matalea caroliniensis* (S1); *Cyperus refractus*, a new state record; and finally, the wetland shrub *Cornus stricta* (unofficially a new state record apparently overlooked by Tatnall, although previously recorded for the state by W. S. Taber in *Trees of Delaware* (1930). Old spoilage and dredge pits along the C & D Canal were found to contain unusual pond, bank, and ridge habitats where we discovered *Juncus diffusissimus* and *Aristida curtisii*, both new state records; the latter was found growing with a small population of *Hudsonia tomentosa* (S4), not previously recorded for New Castle County. A freshwater impoundment provided the first modern collection of *Cicuta bulbifera* (former SX), not seen in more than a century. *Limnobium spongia* (a former SH), and *Utricularia gibba* (S2) were also found at this site.

On the Coastal Plain into Kent County, finds in the western part of the county included *Sporobolus clandestinus*, *Lespedeza stuevei* (both former SH species), *Commelina erecta* v. *angustifolia* (S1), *Paronychia fastigiata* (S1), and another population of *Cyperus refractus*. Several late-season forays yielded more populations of *Leptoloma cognatum* and small colonies of *Quercus prinoides* (S1) and *Pycnanthemum torrei* (S1). Finally, explorations along the New Castle County coastline turned up several populations of *Leptochloa fascicularis* v. *maritima* within disturbed wetlands habitats; this indicates that it may be found more frequently in similar situations in the future. These rare plant surveys were funded by the Delaware Natural Heritage Program. JANET EBERT AND JACK HOLT

PENNSYLVANIA SCIENCE OFFICE OF THE NATURE CONSERVANCY 1993 VEGETATION SURVEY HIGHLIGHTS. During the 1993 field season biologists from The Nature Conservancy's Pennsylvania Science Office (PSO) conducted county natural areas inventories (CNAI) in Sullivan and Wyoming counties. Surveys of sites identified from aerial photographs and historical data helped us locate several new sites for state-listed plant species (Dept. Environmental Resources 1987, 1993) in the two counties. Nomenclature is that used by Rhoads & Klein (1993). State Satus is from Title 25, Chapter 82: Conservation of Pennsylvania Native Wild Plants (Dept. of Environmental Resources 1987, 1993).

Jacob's Ladder (*Polemonium van-bruntiae* Britt.), Pennsylvania Endangered, was located in one forested swamp in eastern Sullivan County. There are several vague historical records from this vicinity but recent searches had been unsuccessful (A. E. Schuyler, pers. comm.); the species was last reported in 1934. The only other known extant site in Pennsylvania is in Wayne County. The Wayne County population has been declining for several years and was reduced to one plant as of 1993. This site in Sullivan County may represent the only viable population of this species in Pennsylvania.

Floating bladderwort (*Utricularia radiata* Small) had been seen last in 1927 in southern Bucks County and was believed extirpated (Rhoads & Klein 1993). Populations were found in two lakes in eastern Sullivan County while conducting searches for *Potamogeton confervoides*. Its discovery makes it a Pennsylvania Endangered species (Dept. of Environmental Resources 1987).

Slender cliff-brake (*Cryptogramma stelleri* (Gmel.) Prantl), a Pennsylvania Endangered fern, was found at one new location in western Sullivan County. The population is only the fifth extant in the state and appears to be the second largest.

Tuckerman's pondweed (*Potamogeton confervoides* Reichenb.), Pennsylvania Threatened and a candidate for listing under the Endangered Species Act, was located at two new sites in western Wyoming County during the CNAI. One of the two new sites is a small glacial kettlehole lake with several homes around it and the other is a beaver pond located on state game lands. We also attempted to find it at several other known sites in the two-county area as part of a separate wetland plant contract. Only one of the species' known sites could be reconfirmed. At the time, October 1993, the population appeared on the verge of being crowded out by another aquatic plant.

Also noteworthy were new populations of several other listed species discovered during the CNAI. These include five locations for creeping snowberry (*Gaultheria hispidula* (L.) Muhl. ex Bigel.), four locations for Labrador tea (*Ledum groenlandicum* Oeder) and one for bog sedge (*Carex paupercula* Michx.), a county record.

These County Natural Areas Inventories are supported by the individual counties and by the PA Department of Community Affairs through Recreational Improvement and Rehabilitation Act grants. The wetland plants survey was sponsored through a grant to the Dept. of Environmental Resources from the United States Environmental Protection Agency under the Clean Water Act's 1993 State Wetlands Protection Development Grant Program.

The information on rare species and exemplary natural communities from the CNAIs is contributed to the Pennsylvania Natural Diversity Inventory data base. The PSO works in cooperation with the Western Pennsylvania Conservancy and the Bureau of Forestry, PA Department of Environmental Resources, to maintain the PNDI data base of the state's rarest species, exemplary natural communities, geologic features and managed areas. As of this writing, there are over 11,000 extant and historical records of plants, animals and communities.

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ANTHONY F. DAVIS, JULIE A. LUNDGREN AND JOHN R. KUNSMAN

Bartonia No. 59: 138-142, 1996

1993 FIELD TRIPS

16 May: Furnace Hills, Lancaster Co., PA. We hiked through the gamelands to see numerous plants of *Galearis spectabilis*, *Trillium cernuum*, *Cypripedium pubescens* (nearly past bloom), *Adlumia fungosa*, *Hydrastis canadensis*, *Triosteum aurantiacum*, and *Rhododendron periclymenoides*. At Camp Shan area we saw *Aplectrum hyemale* and *Waldsteinia fragarioides*. At Middle Creek Wildlife Management Area we saw a stand of about 200 plants of *Isotria verticillata* in full bloom within an area of 20 square feet. A small group ventured to Shenk's Ferry to see *Corallorhiza wisteriana* in peak bloom. Leaders: Tim Draude and Mark Larocque.

22 May: Woodlands Cemetery, 40th St and Woodland Avenue, Philadelphia, PA. Formerly the country estate of William Hamilton, the Woodlands was an impressive landscape garden in the 18th and early 19th centuries. John Lyon and Frederick Pursh worked as gardeners and plants from the Lewis and Clark expedition were cultivated here. *Ginkgo biloba*, *Populus nigra* "Italica", *Ailanthus altissima*, and *Acer platanoides* were introduced into cultivation in North America at the Woodlands. To get some idea of what is there now, we recorded the following woody plants: *Acer pseudoplatanus*, *A. rubrum*, *Aesculus hippocastanum*, *Broussonetia papyrifera*, *Buxus sempervirens*, *Castanea mollissima*, *Celtis occidentalis*, *Chamaecyparis pisifera*, *Fraxinus americana* var. *biltmoreana*, *Ginkgo biloba*, *Gleditsia triacanthos*, *Gymnocladus dioica*, *Juglans nigra*, *Liquidambar styraciflua*, *Morus rubra*, *Picea pungens*, *Prunus serotina*, *Quercus palustris*, *Q. rubra*, *Sassafras albidum*, *Sophora japonica*, *Styrax japonica*, *Taxus baccata*, *T. cuspidata*, *Thuja orientalis*, *Tilia americana*, *T. cordata*, *Ulmus* sp., *Zelkova serrata*. Leader: Alfred E. Schuyler.

5 June: Muskee Creek, Manumuskin River, Tuchahoe River watersheds, Pine Barrens of Atlantic and Cumberland cos., NJ. We stopped at an open cedar bog in the Lawrens Branch of the Manumuskin to see excellent stands of *Eriocaulon compressum* and *Orontium aquaticum* in flower. *Arethusa bulbosa* in bloom and *Pogonia ophioglossoides* in bud were also noted, as well as fine stands of *Kalmia latifolia* and *K. angustifolia* in the adjacent pine-oak uplands. At Aetna Furnace along the Tuckahoe we saw patches of *Liparis liliifolia* on mounds of slag with *Ophioglossum vulgatum* and *Pyrola americana*. In an old timber cut in the Muskee Creek headwaters we noted a state record *Chamaecyparis thyoides* with a cbh of 9 ft 7.5 in. The sedge genus *Carex* was studied throughout the day and the following species were noted: *C. abscondita*, *C. albicans* v. *emmonsii*, *C. albolutescens*, *C. annectens*, *C. atlantica*, *C. barrattii*, *C. bullata*, *C. canescens*, *C. collinsii*, *C. crinita*, *C. debilis*, *C. exilis*, *C. folliculata*, *C. howei*, *C. lurida*, *C. intumescens*, *C. nigromarginata*, *C. pensylvanica*, *C. swanii*, *C. striata*, *C. stricta*, and *C. trisperma*. Leader: Gerry Moore.

12 June: Nockamixon State Park and Haycock Mountain, Bucks Co., PA. We stopped along PA route 563 to see one of the five extant locations in the state for *Phlox pilosa*. Other plants seen along the road include *Krigia biflora*, *Linum intercursum*, *Lobelia spicata*, *Pedicularis canadensis*, and *Scutellaria integrifolia*. At Thatcher Road meadow we noted *Phlox maculata*, *Castilleja coccinea*, *Liatris spicata*, and *Lilium canadense*. At the Parkway Diner a Wood Turtle, *Clemmys insculpta*, was observed eating the ripened fruits of *Fragaria virginiana*. Along the 0.5 mile trail to the top of Haycock Mountain, >50 species were

encountered, including *Adlumia fungosa*, *Obolaria virginica*, *Goodyera pubescens*, *Rubus odoratus*, and a single plant of *Liparis liliifolia*. *Botrychium virginianum* was abundant and very ripe, producing large clouds of spores when touched. Leader: Greg Edinger.

13 June: Tyler Arboretum, Lima, Delaware Co., PA. This trip focused on the Pink Hill serpentine barren and nearby woods. Noteworthy species included *Pryrola virens*, *Ilex verticillata*, *Chimaphila maculata*, and *Phlox subulata*. Leader: John Ballas.

19 June: Pennypacker Mills County Park, Schwenksville, Montgomery Co., PA. Several areas of the park have been allowed to revert to "natural" conditions that may have prevailed during Governor Pennypacker's ownership. In the first entrance field, which is moist, and in a nearby wooded area, we encountered 26 species of carices, including *Carex squarrosa*, *C. bushii*, *C. hirtifolia*, *C. conoidea*, *C. glaucodea*, *C. laxiculmis*, and *C. lanuginosa*. There were many attractive wild flowers blooming such as *Lobelia spicata*, *Salvia lyrata*, and *Mentha* spp. At the nearby property of club members Goeffrey Kaiser and Bruce Grimes, we enjoyed a bountiful habitat of woodlands, wetlands, stream, and field. Leaders: Ann Newbold and Heinrich Zoller.

20-24 June: Lancaster, PA. The 1993 Joint Field Meeting of the Philadelphia Botanical Club, the Torrey Botanical Club, and the Northeastern Section of the Botanical Society of America was housed at Millersville University near Lancaster. There were three full days of field trips. Localities visited included the Furnace Hills area in northern Lancaster County; serpentine barrens in southern Lancaster County; limestone cliffs in central Lancaster County; and areas along the Susquehanna River in Lancaster and York counties. Trip leaders were Timothy Draude, William Olson, Roger Latham, Ann Newbold, and Fred Habegger. Evening speakers included Stephen Sylvester, who discussed the geological resources of the Lancaster area; Roger Latham, who spoke about Pennsylvania's serpentine and glacial till barrens; Guy Steucek, who presented a program about Lancaster County woodlands; and Mike Batcher, who program dealt with the management of threatened flora and fauna. As a result of aggressive development, degradation of water resources, or invasion by exotic plant species, little remains of the native woodlands of Lancaster County. There are bright spots, however: small patches of native plants are being protected by the Nature Conservancy and other local organizations, and there are efforts to link remaining core habitats with riparian corridors. The chairperson was Cyane Gresham, and the treasurer, Karl Anderson.

10 July: Tyler Arboretum, Lima, Delaware Co., PA. We visited the Pink Hill serpentine barren particularly to see the beautiful display of *Lilium philadelphicum*. Noteworthy associated species were *Oenothera fruticosa*, *Lobelia spicata*, and *Ceonothus americanus*. Leader: John Ballas.

11 July: Green Acres Natural Area, Medford Leas, Burlington Co., NJ. We were invited by the Arboretum Oversight Committee of Medford Leas to conduct a field trip of their Natural Area for the express purpose of updating their species list, developed by the leader in 1992. The Natural Area is comprised of four major inner coastal plain communities: 1) palustrine nontidal emergent wetland, 2) palustrine forested wetland, 3) mesic mixed oak forest, and 4) successional forests (one of mature *Pinus virginiana*; the other of young *Liquidambar styraciflua*). Focus was on the palustrine forested wetland along Sharp's Run and Southwest Branch of Rancocas Creek (= Haynes Creek). Situated at the foot of a steep slope, this rich floodplain, underlain by sandy loam with some glauconite content, is characterized by a mixed forest community of fast-growing hardwoods. Important trees, several of them huge specimens, include *Acer rubrum*, *Platanus occidentalis*, *Magnolia*

virginiana, *Salix nigra*, *Quercus palustris*, *Q. falcata*, *Fraxinus americana*, *Liriodendron tulipifera*, *Liquidambar styraciflua*, *Ulmus americana*, *Carya* spp., *Prunus serotina*, *Carpinus caroliniana*, *Ilex opaca*, *Betula nigra*, and some *Acer saccharinum*, *Cornus florida*, and *Sassafras albidum*. Common shrubs and vines scattered throughout are *Lindera benzoin*, *Viburnum dentatum*, *V. prunifolium*, *Cornus amomum*, *Toxicodendron radicans*, *Euonymus americanus*, *Vaccinium corymbosum*, *Clethra alnifolia*, *Ilex verticillata*, *Sambucus canadensis*, *Parthenocissus quinquefolia*, and *Mitchella repens*. A typical diverse herb layer also prevails, including such species as *Impatiens capensis*, *Lobelia cardinalis*, *Chelone glabra*, *Caltha palustris*, *Anemone quinquefolia*, *Podophyllum peltatum*, *Aquilegia canadensis*, *Symplocarpus foetidus*, and an array of ferns. Although infused with various plantings (including exotic species) by the residents, this palustrine forest has retained its native character and anticipated species composition. We added 13 taxa not previously recorded: *Chenopodium album*, *Polystichum acrostichoides*, *Deparia acrostichoides* (= *Athyrium thelypteroides*), *Dryopteris carthusiana*, *Potamogeton epihydrus*, *Ceratophyllum demersum*, *Acer platanoides*, *Ulmus rubra*, *Corylus americana*, *Poa pratensis*, *Solanum dulcamara*, *Physalis subglabrata*, and *Rudbeckia laciniata*. The communities we examined were well known to Witmer Stone, who explored the Medford flora at the turn of the century, documenting some 750 species while based at a cabin almost on site. In comparing some of our discoveries to those reported by Stone (1911), we were surprised, for example, by his omission of *Acer saccharinum* and *Fraxinus americana*. Of the former Stone says "sparingly southward within our limits"; of the latter (of which we saw huge specimens) he states "rare southward." Finally, all were given an opportunity to see the largest reported hickory in the state: a Bitternut, *Carya cordiformis*, with a cbh of 13 ft 3 in. Leader: Ted Gordon.

14 August: Smithville Mansion and other parks in western Burlington Co., NJ. At Mill Creek Park in Willingboro, high water levels kept us from fully exploring the intertidal zone, but we did find *Lobelia chinensis*, a rapidly-spreading adventive, in bloom at the high tide line on a sandy shore. In the same area were *Eleocharis erythropoda*, *Lycopus rubellus*, and *Helenium autumnale*. Upland woods nearby had *Physocarpus opulifolius* and an unusually large stand of *Lycopodium obscurum*, while the shores of a small, stagnant pond produced *Eclipta prostrata*, *Hypericum mutilum*, and *Veronica anagallis-aquatica*. At the Rancocas Nature Center in Westhampton, the shores of a nearby pond produced *Zizania aquatica*, *Triadenum virginicum*, *Rhexia mariana*, *Juncus acuminatus*, *Rhynchospora capitellata*, *Galium tinctorium*, *Utricularia gibba*, and many other species. Wood edges had *Humulus lupulus* and *Juglans cinera* growing near *J. nigra*. Finally, the shores of Smithville Lake in Easthampton Township had *Lobelia cardinalis* in good bloom, with *Verbena hastata* and *Ascelpias incarnata*, *Mikania scandens*, *Apios americana*, *Lysimachia terrestris*, *Carex crinita*, and *Lindernia dubia* also present. Of particular interest here were numerous plants of *Azolla caroliniana*, growing with *Lemna* in warm, shallow water; this floating fern, seldom seen in New Jersey, was first noticed here in 1992. The liverwort *Riccia natans* was also observed. Leader: Karl Anderson.

15 August: Savannahs and Cedar Swamps, Batsto River, Burlington Co., NJ. Extending along ancient oxbows and coves, the cedar swamps, savannahs, and quaking bogs of the Batsto River above the village of Batsto attracted botanists as early as 1805 and, perhaps, even earlier. On a savannah well above the village, we had little difficulty finding our target species: *Rhynchospora oligantha*, *Xyris fimbriata*, *Schizaea pusilla*, and flowering specimens of about a dozen *Platanthera integra* and two *P. cristata*. The remarkably diverse flora

encountered here included many other rare as well as common species: *Nathecium americanum*, *Juncus caesariensis*, *Muhlenbergia torreyana*, *Carex livida*, *Pogonia ophioglossoides*, *Platanthera clavellata*, *Calopogon tuberosus*, *Hypericum denticulatum*, *Sabatia difformis*, *Lophiola aurea*, *Lobelia canbyi*, *L. nuttallii*, *Rhynchospora cephalantha*, *R. alba*, *R. gracilenta*, *R. fusca*, *Xyris torta*, *Iris prismatica*, *Polygala cruciata*, *Smilax laurifolia*, *Scleria reticularis* v. *pubescens* (= *S. muhlenbergii*), *Cladium mariscoides*, *Orontium aquaticum*, *Calamovilfa brevipilis*, *Eleocharis robbinsii*, *E. tuberculosa*, *Proserpinaca pectinata*, the typical carnivorous plants, *Sphagnum cyclophyllum*, and *S. portoricense* (the latter, a new record). In shallow water along the margins of the stream, we observed *Utricularia purpurea*, *Potamogeton confervoides*, *Nymphoides cordata*, *Sclerolepis uniflora*, *Peltandra virginica*, *Pontederia cordata*, *Sagittaria latifolia*, and *Eriocaulon decangulare*. At the request of the N.J. Forest Service, we conducted a survey for successional herbs at a 1989-1991 cedar clearcut of 3.4 hectares at Penn Swamp Branch west of the Tuckerton Trail. Prior to the harvest, a mature *Chamaecyparis* stand with a sparse herb layer occupied this site, which now serves as a cedar regeneration experimental plot. The site produced a substantial sum of 40 species of herbs, vines, and ferns. Although no rare species were encountered, we were surprised by the occurrence of *Bidens polylepis*, an interloper. Leader: Ted Gordon.

21 August: Sandy Branch, New Castle Co., DE. Along the western border of Delaware but just across the state line in Maryland, we observed a small population of *Luzula acuminata* in a vegetative state. (This taxon has only been recorded once in Delaware.) On the edge of a somewhat drawn-down beaver impoundment, we saw extensive stands of *Deschampsia flexuosa* on the slopes of an open chestnut oak stand. Along an adjacent powerline cut we observed the following species, a number of which are normally found only in the Piedmont: *Cacalia atriplicifolia* (mostly finished flowering), yards away from a pocket of *Lycopodiella appressa*, *Helianthemum propinquum*, *Lechea villosa*, *Castanea pumila*, and *Euphorbia ipecacahuanae*. In a dry meadow above and near the cut, a single stem of *Cyperus refractus*, at only its second Delaware station (it was only found int he state this year), grew with *Euphorbia corollata*, *Croton glandulosus*, and *Cenchrus* sp. On the moister trail down from the meadow *Elephantopus carolinianus* was blooming, and further along more typically Piedmont species as *Lactuca floridana*, *Cimicifuga racemosa*, and *Polystichum acrostichoides*. Toward the end of the uncultivated section of the powerline cut, we observed *Paronychia canadensis* along a wood edge and on a side trail, *Ceonothus americanus*, a large but local population of *Helianthus divaricatus*, and a small colony (long past flowering) of *Silene virginica* at one of only two known Delaware stations. Finally, the leaders had planned to take the group a few miles north to see a population of *Matalea caroliniensis* on the Delaware/Maryland state line, but conveniently we found a small but very large-leaved colony in flower along a rich wooded trail near the powerline cut. Leaders: Jack Holt and Janet Ebert.

11 September: Batsto River, Burlington Co. and Route 30, Atlantic Co., NJ. We ventured into Long Savannah along the eastern side of the Batsto River hoping to see *Spiranthes laciniata*. We were unsuccessful, although our search of the previous year had produced approximately 15 scattered plants here. Among the species seen wee *Aster nemoralis*, *A. novi-belgii*, *Eriocaulon decangulare*, *Schizaea pusilla*, and *Hypericum canadensis*. A few miles east of Hammonton along Route 30 we examined a fine station of >100 *Gentiana autumnalis* with about 50% of the plants in bloom. Associated species in full bloom were *Heterotheca* (*Chrysopsis*) *mariana*, *Liatris graminifolia*, *Aster gracilis*, and *A. spectabilis*.

Leader: Mark Larocque.

18 September: Washington Park, Washington Township, Gloucester Co., NJ. It appears that this central Gloucester County park had not been botanized previously by the club. Trails, edges of fields, a series of young woodlands, and a few patches of mature forest composed of plants common to the inner coastal plain were examined during intense downpours. A significant feature was the presence of an Atlantic White Cedar swamp supporting a number of common species associated with this community: *Carex striata*, *Chamaedaphne calyculata*, *Drosera rotundifolia*, *Juncus canadensis*, and many others. Observed elsewhere on the site were *Chelone glabra*, *Juncus validus* (a new station for the county), *Myrica heterophylla*, *Toxicodendron vernix* (dense in most red maple swamps), *Aster novi-belgii*, *Agalinis purpurea*, and *Cyperus rivularis*. Leader: Joe Arsenault.

Bartonia No. 59: 143-146, 1996

1994 FIELD TRIPS

1 May: Fern Hill Farm, Gloucester Co., NJ. Club members toured the woodland garden of this landscaped farm owned by the leaders. Many spring woodland ephemerals were in bloom, including 18 species of trillium. Photographers in the group had a fine opportunity for closeup photography at a leisurely pace. Leaders: John and Janet Gyer.

7 May: Williamson Park and Shenk's Ferry, Lancaster Co., PA. We ventured onto a limestone outcrop overlooking the Conestoga River to see *Dodecatheon amethystinum* (Pink Shooting Star), *Arabis lyrata* (Lyre-leaf Rockcress), *Aquilegia canadensis* (Columbine), and *Pellaea atroupurpurea* (Purple-stem Cliffbreak). At Shenk's Ferry Wildflower Preserve in the southern part of the county, we saw many spring flowers, including *Mertensia virginica* (Virginia Bluebells), *Polymnia canadensis* (White-flower Leafcup), *Hybanthus concolor* (Green Violet), *Triosteum aurantiacum* (Wild Coffee), *Phlox maculata* (Wild Sweetwilliam) and *Corallorhiza wisteriana* (Spring Coralroot). Leader: Mark Larocque.

11 June: Atsion and Penn Swamp Branch, Wharton State Forest, Burlington Co., NJ. Within the confines of the old "village" of Atsion were fine clusters of *Opuntia humifusa*, thickets of fruiting *Prunus maritima*, and extensive cushions of flowering *Minuartia caroliniana*. Along the abandoned railroad tracks nearby, we briefly explored a pitch pine lowland forest (including moist depressions) with a history of frequent wildfire. Here we noted in anthesis *Melampyrum lineare*, *Iris prismatica*, *Panicum mattamuskeetense* (= *Dichanthelium dichotomum* var. *dichotomum*), and *Fimbristylis puberula*. Not yet in flower were *Muhlenbergia torreyana* and *Crotonopsis elliptica* (Rushfoil), a tiny, wiry, branched plant with a silvery aspect, growing in exposed sand. At our next stop, the primary mission was to search the wetland along Penn Swamp Branch (= Goodwater Run), a small Batsto tributary southeast of Quaker Bridge, for a small population of *Eriophorum tenellum* (Few-nerved Cottongrass). However, an intensive search for this state-endangered sedge, last observed here in the late 1960s, was unsuccessful. Within expansive Penn Swamp Pond, ringed by *Chamaedaphne calyculata*, we focused on the shallow, upper half, comprised of *Carex exilis* and *C. atlantica* hummocks associated with *Chamaecyparis thyoides*, *Lophiola aurea*, and *Pogonia ophioglossoides*, the latter two in bud. Flowering species included *Utricularia fibrosa*, *U. subulata*, *Rhynchospora fusca*, *Eriocaulon compressum*, *Vaccinium macrocarpon*, and *Gaylussacia dumosa*. Areas of somewhat deeper water were dominated by *Cladium mariscoides*, while less saturated zones contained patches of *Muhlenbergia torreyana*. It appears that beaver activity has resulted in raising more permanently the water level of this complex. With difficulty we also penetrated a mature cedar forest northeast of the pond. A number of the larger trees were well over 100 years old. Windthrown trunks lay helter-skelter. Beneath a typical ericaceous shrub layer, shaded carpets of sphagnum mosses harbored only a few species: *Carex collinsii*, *Mitchella repens*, *Thelypteris palustris*, and fine patches of *T. simulata*. Future searches for *Eriophorum tenellum* should focus on the 0.7 mile long wetland corridor extending west of the pond to a small bridge downstream, nearer the Batsto River. Leader: Ted Gordon.

26-30 June: Frostburg, MD. The 1994 Joint Field Meeting of the Philadelphia Botanical Club, the Torrey Botanical Club, and the Northeastern Section of the Botanical Society of

America was housed at Frostburg State University in western Maryland. There were three full days of field trips. Localities visited included Green Ridge State Forest, Finzel Swamp, the Frostburg City Watershed, and the C & O Canal in Maryland; and Larenim County Park and Dolly Sods in West Virginia. Habitats seen included shale barrens, flood plains, shrub swamps, deciduous woodlands, heath barrens, and grass balds. Evening programs included an overview of Natural Communities of Western Maryland, by Edward Thompson of the Maryland Department of Natural Resources; a look at the Geology of Western Maryland, by Dr. Tom Small of the Frostburg State University Geology Department; a Survey of the Herbaceous Flora in two Western Maryland Counties, by Dr. James Howell of Allegany Community College; a discussion of the Trilliaceae, by Dr. Victor Soukup; and a program about the Vegetation of the Gauley and Bluestone Rivers, by Dr. Bill Grafton of West Virginia University. The Chairperson was Simon Dadydeen, of the Biology Department of Frostburg State University; the Treasurer was Karl Anderson.

10 July: Taylor's Preserve, Cinnaminson, Burlington Co., NJ. This trip investigated wood edges, the margins of cultivated fields, shallow freshwater wetlands, and the gravelly intertidal zone of the Delaware River. A list of 207 plants was compiled, of which 80 were non-native species, as might be expected in a long-farmed, disturbed site. A copy of the list is available on request. Some less-common species included *Cyperus microiria*, *Carex frankii*, *Galinsoga parviflora,* and some very large, old, planted specimens of *Quercus macrocarpa*. A single plant of *Polygonum perfoliatum* was found; this is the second reported location for this invasive introduced plant in New Jersey, and the first record for Burlington County. Another introduction, *Lobelia chinense* (in bloom), dominated the intertidal zone, growing with *Rumex verticillatus* and scattered plants of *Amaranthus cannabinus*, *Myosotis laxa*, and a non-flowering *Polygonum* sp. In addition to plants, numerous species of butterflies and birds enlivened the trip. Leader: Karl Anderson.

18-28 July: Our club experienced a first—an out-of-bounds trip to Europe. Joined by a number of American Botanical Society members, we traveled to Switzerland, primarily to see its bountiful flora under the botanical supervision of one of the foremost taxonomists of Switzerland, Dr. Heinrich Zoller, Professor Emeritus of the University of Basel. From Zurich we looped through the Alps using a boat on Lake Lucerne, rackrailways on the subalpine Central Alps, our own bus through mountain passes, a bus-on-a-train through tunnels much too long to hold your breath, and cable cars for the upper alpine stages, botanizing all the way (whenever we weren't catching our breath from the wonder of the scenery). At Zermatt we viewed the Matterhorn from Hotel Riffelberg very high up on its magnificent slope, then walked to the celebrated Gorner Glacier where we picnicked on one of our delicious Swiss lunches (hard bread, cheeses, yogurt, fruit and Swiss chocolate). The plants we saw and named were legion, including gentians, tiny and blue, tall and yellow, orchids by the dozens, species of *Campanula*, *Silene*, and *Saxifraga*, and of course the not-to-be-forgotten Edelweiss growing alongside our trail. Leaders: Henrich Zoller, Max Seiler of the Basel Botany Club, and Ann Newbold.

23 July: Millersburg, Dauphin Co., PA. We Ventured into a wet meadow along the Susquehanna to see 75-100 *Platanthera peramoena* in mid-bloom. Other flowering plants here were *Ascelpias incarnata*, *Vernonia noveboracensis*, and *Rudbeckia laciniata*. Invasive grasses seem to have had a detrimental effect on the orchid's habitat. The past two years there have been >200 robust specimens (4-5 ft tall) of the Purple Fringeless Orchid. We traveled to Route 324 to see a roadside cut with a dozen plants of *Platanthera ciliaris*, *Goodyera pubescens*, *Epipactis helleborine*, *Sabatia angularis*, and a puzzling *Eupatorium*

sp. Leader: Mark Larocque.

6 August: Malaga Lake and Vicinity, Franklin Township, Gloucester Co. and Upper Pittsgrove, Salem Co., NJ. We explored both the west shore of Malaga Lake and walked the broad, shallow bottom of the upper reaches of the lake. The disturbed shoreline at the end of Malaga Drive supported *Rhynchospora capitellata*, *R. macrostachya*, *R. chalarocephala*, *Eleocharis olivacea*, *E. tuberculosa*, *E. robbinsii*, *Cyperus rivularis*, *Dulichium arundinaceum*, *Rhexia virginica*, *Lycopus uniflorus*, *Juncus canadensis*, *J. pelocarpus*, *Panicum longifolium*, *Vaccinium macrocarpon*, and *Apios americana*. In the lake submerged species such as *Utricularia purpurea* and *U. fibrosa* were intertwined with floating leaved plants of *Nuphar lutea*, *Nymphaea odorata*, and *Nymphoides cordata*, forming dense beds. Half of the group explored a dense *Chamaecyparis* swamp along the Scotland Run stream corridor above the main body of the lake. The shallow water surrounding the cedar stand supported the same submerged and floating-leaved species listed for the lake, in addition to *Decodon verticillatus*, *Rhynchospora fusca*, *R. alba*, *Carex canescens*, *Eleocharis tenuis*, *Triadenum virginicum*, *Xyris difformis*, *Drosera filiformis*, *D. rotundifolia*, and *D. intermedia*. The other half of the group concentrated on the oak-pine forest west of the lake. This forest supported all of the typical oaks and pines as well as *Carya pallida*, *Cornus florida*, *Dichanthelium villosissimum*, and *D. acuminatum*. On Nature Conservancy property in Brotmanville, we investigated a small portion of a large tract of land west of the Maurice River, north of Garden Road. Here a sand mine and surrounding disturbed land contained *Hudsonia ericoides* and *Monarda punctata*, and *Carya pallida* was a significant component of the oak-pine forest. A series of paths leading into red maple swamp bordering the Maurice River led to pockets of *Toxicodendron vernix*. Leader: Joe Arsenault.

6 August: Montauk Point, Long Island, NY. The focus of this joint trip with the American Association of Field Botanists was orchids. We visited a roadside cut in Riverhead to see *Malaxis bayardii*, which differs from the similar *M. unifolia* in flower structure and overall habitat range. At Napeague Harbor we saw the newly described *Platanthera pallens*, which has been separated from *P. cristata* on the basis of flower structure. Field examination of the two revealed significant differences in the lip, petals, and coloration. The lip of *P. pallens* is significantly recurved, and the flower is a pale yellow. We also saw a large population of *Sabatia stellaris* in a salt marsh adjacent to the *P. pallens* population. Finally, we visited several coastal pond shores to see *Coreopsis rosea* and *Gratiola aurea*. Leaders: Eric Lamont and Mark Larocque.

13 August: Martha Furnace and Oswego River, Burlington Co., NJ. We immediately began exploring the diverse flora of the savannahs, quaking bogs, and cedar swamps that border the Oswego above Martha. The presence of several flowering species of bladderwort in close proximity allowed for convenient comparison. We examined *Utricularia fibrosa*, *U. cornuta*, *U. juncea* (including forma *virgatula*), the tiny pinheads of *U. subulata* forma *cleistogama*, and the delicate purple flowers of a few lingering specimens of *U. resupinata*. Widely distributed species included *Rhynchospora fusca*, *R. alba*, *Eleocharis robbinsii*, *E. tuberculosa*, *Muhlenbergia uniflora*, *Cyperus dentatus*, *Xyris torta*, *Juncus canadensis*, and *J. pelocarpus*. Occupying congenial pockets were *Sabatia difformis*, *Agalinis virgata*, *Rhexia virginica*, *Polygala cruciata*, and *P. brevifolia*, each contributing a speck of color. Jutting from the stream bed were robust specimens of *Xyris smalliana*, with their prominent beet-red bases. Conspicuous on extensive carpets of sphagnum mosses were the large goblets of *Sarracenia purpurea*, associated with dense ranks of *Narthecium americanum* and *Lophiola aurea*, both gone to seed. Only a few plants of *Tofieldia racemosa* were seen. Despite

diligent search of this savannah, we did not relocate *Rhynchospora oligantha*, a rare sedge first seen here by the leader in 1975. However, we did rediscover two small patches of rare peat mosses, *Sphagnum angustifolium* and *S. portoricense.* On a gentle slope nearby were *Schizaea pusilla*, *Lycopodiella caroliniana*, and the foliage of *Platanthera blephariglottis.* In a spung below the site of Martha Furnace, we encountered *Rhynchospora gracilenta*, *Juncus caesariensis*, *Scleria reticularis* v. *pubescens*, several flowering stems of *Ludwigia hirtella*, and *Platanthera clavellata* in fruit. A short search in this vicinity failed to turn up a recently extant population of *Ophioglossom vulgatum.* Leader: Ted Gordon.

10 September: Chesapeake and Delaware Canal, New Castle Co., DE. After assembling in Glasgow, we journeyed to an assortment of shallow ponds in dredge spoil on the north side of the canal. There we observed such species as *Elocharis quadrangulata*, *E. olivacea*, and *Schoenoplectus purshianus* in well defined wetland zonal communities, along with *Juncus diffusissimus* and, on nearby sandy soil, *Cyperus grayii*, usually found on beach dunes. We visited a tidal ditch paralleling the south side of the canal. Here we found *Sagittaria calycina* and *Potamogeton foliosus.* Our last stop was a sandy spoil deposit at the southeast end of the canal, where we observed a small population of *Hudsonia tomentosa*, but found that we were too early for *Aristida dichotoma* var. *curtissii.* Leaders: Jack Holt and Janet Ebert.

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EDITOR'S NOTE

Biographical Accounts of Hans Wilkens and Grace M. Tees will be published in Bartonia No. 60. Friends and colleagues of Hans and Grace are encouraged to provide information to the editor concerning things they remember about them. As many know, both made substantial contributions to support botany at the Academy of Natural Sciences and were longtime members of the Philadelphia Botanical Club.

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Program of Meetings 1993 and 1994

Date	*Subject*	*Speaker*
1993		
28 Jan	Toluene Removal from Indoor Air by *Dieffenbachia*	John R. Porter
28 Feb	Changes in the Flora of Northeastern Bucks County, 1890-1990	Ann F. Rhoads
25 Mar	Flowers of the Swiss Alps	Heinrich Zoller Ann Newbold
22 Apr	Recent Rare Plant Surveys in Pennsylvania	John Kunsman
27 May	The Foliage is the Fruit Hypothesis and the Sexual Specialization of the Female Inflorescence of Buffalograss	James A. Quinn
23 Sep	Slide Illustrated Report of Summer Botanizing	Club Members
28 Oct	Natural History of Water Plants	Alfred E. Schuyler
18 Nov	Native Azaleas and Rhododendrons of the Eastern United States	Jim Plyler
16 Dec	Woodland Gardens Close Up: Pollination Mechanisms and Seed Production	John and Janet Gyer
1994		
24 Feb	A Visit to Lake Baikal in Southern Siberia	Ann Rhoads
24 Mar	Alpine Wildflowers of Colorado and Wyoming	Sioux Baldwin
28 Apr	Botanical Diversity in the Moist Forests of Southern Bahia, Brazil	Wayt Thomas
26 May	Walnford: An Historic Landscape Restoration	Elizabeth McLean
22 Sep	Slide Illustrated Report of Summer Botanizing	Club Members
27 Oct	Wetlands and Politics	Charles A. Rhodes
17 Nov	Academy's Treasury of Botanical Literature	Elizabeth McLean Alfred E. Schuyler Howard P. Wood
15 Dec	Botanical Exploration of the Mekong and Yangtzi River Divide in Northwest Yunnan, China	Harold Sweetman